Quality Assurance Project Plan
Bear Run Mine

June 1, 2012
MMA Project Number 2507-11

by McVehil-Monnett Associates, Inc.

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A PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

BEAR RUN MINE
QUALITY ASSURANCE
PROJECT PLAN

Revision – Original

Approved By:

Bear Run Mine

Mark Sebree Operations Manager	____________________ Signature	__________ Date

MMA Personnel

William Monnett Air Program Manager	____________________ Signature	__________ Date
James Kuenning Quality Assurance Manager	____________________ Signature	__________ Date

U.S. EPA Region V Personnel

(Name)____________________ (Title)	____________________ Signature	__________ Date
(Name)____________________ (Title)	____________________ Signature	__________ Date

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A3 DISTRIBUTION LIST

Table A3-1: QAPP Distribution List

Personnel	Organization	Title	Email Address	Business Address	Telephone Number
__________	(U.S. EPA)	__________	__________	__________	__________
Forrest Crowe	Peabody Midwest Mining, LLC	Environmental Engineer/Site Operator	FCrowe@PeabodyEnergy.com	Bear Run Mine 7255 East CR 600S Carlisle, IN 47838	(812) 659-7119
Bryce West Scott McGarvie	Peabody Midwest Mining, LLC	Director of Environmental Affairs Sr. Manager of Environmental	BWest@PeabodyEnergy.com SMcgarvie@PeabodyEnergy.com	Peabody Energy 7100 Eagle Crest Blvd. Evansville, IN 47715	(812) 434-8580 (812) 434-8593
William Monnett James Kuenning Ray Roetman	McVehil-Monnett Associates	Project Manager Quality Assurance Manager Air Program Manager	bmonnett@mcvehil-monnett.com jkuenning@mcvehil-monnett.com rroetman@mcvehil-monnett.com	McVehil-Monnett Associates 44 Inverness Drive East, Building C Englewood, CO 80112	(303) 790-1332

A4 PROGRAM ORGANIZATION

Peabody Midwest Mining, LLC (PMM) has retained McVehil-Monnett Associates, Inc. (MMA) to operate an ambient air quality program, collect data, and perform all required data reporting to the regulatory agencies. MMA is responsible for maintaining the official approved Quality Assurance Project Plan (QAPP) for the air monitoring program.

The program participants and roles are listed below.

Peabody Midwest Mining, LLC	
Scott McGarvie	Sr. Manager of Environmental
Bryce West	Director of Environmental Services
Forrest Crowe	Environmental Engineer/Site Operator
MMA	
William Monnett	Air Program Manager
Ray Roetman	Air Monitoring Project Manager (Calibrations, Data Analysis, Reporting)
James Kuenning	Quality Assurance Manager (Performance Audits)
U.S. EPA	
______________________	________________________

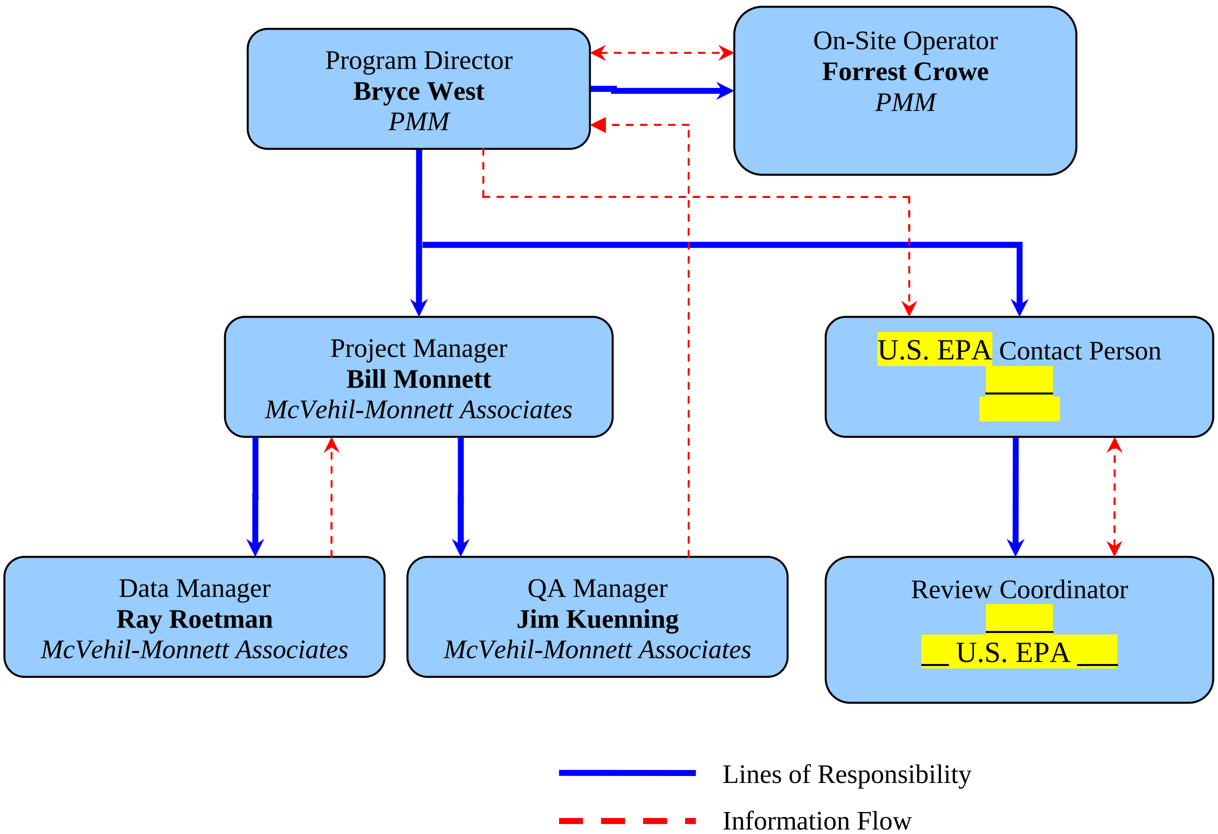

Figure A4-1: Project Organization Chart

A5 PROJECT DEFINITION AND BACKGROUND

The requirements for air quality impact analyses and monitoring programs were originally established by the 1977 amendments to the Federal Clean Air Act and re-authorized by the 1990 Clean Air Act amendments. To comply with the federal and state monitoring regulations and guidelines, a successful ambient monitoring program must develop a quality assurance program including standard operating procedures.

This Quality Assurance Project Plan (QAPP) describes the ambient air quality monitoring program for the PMM Bear Run Mine near the town of Carlisle in southwestern Indiana. This monitoring and quality assurance plan outlines the methods and requirements for the air quality monitoring data collection program.

The ambient monitoring program will collect four months of aerometric monitoring data that meet U.S. Environmental Protection Agency (U.S. EPA) quality requirements for data completeness, accuracy, and validity. The objective is a data recovery rate of at least 75% for air quality data and at least 90% for meteorological data.

The monitoring sites were selected for the reasons listed in the Dust Monitoring Plan, which has been reviewed and approved by U.S. EPA Region V.

PERMIT #256
PERMIT #256-1
UPWIND AIR MONITORING LOCATION #3
DOWNWIND AIR MONITORING LOCATION #2
PIT 1 COAL REMOVAL AND SPOIL AREA
PERMIT #256-3
PERMIT #256-3
DOWNWIND AIR MONITORING LOCATION #1
RAILROAD
RAILROAD
STATE ROUTE 159
STATE ROUTE 159
PERMIT #256-4
PERMIT #256-2
CO. RD. 700 EAST
0 1000' 2000' 3000'
PEABODY MIDWEST MINING, LLC
Evansville , Indiana
FIGURE A5-1:
BEAR RUN MINE -
AIR MONITORING STATION LOCATIONS
LEGEND
AIR MONITORING LOCATION
RESIDENCES OF CONCERN
GREENE-SULLIVAN STATE FOREST
AERIAL: 2-27-12
SULLIVAN CO., IN
DATE: 3-28-12

A6 PROJECT/TASK DESCRIPTION

The following monitoring systems will operate under the Dust Monitoring Plan.

Particulate: PM_{10} concentrations will be continuously monitored using federal equivalent method (FEM) Beta Attenuation Monitors (BAMs) and a federal reference method (FRM) high-volume air sampler, both operated in accordance with U.S. EPA protocols (40 CFR Part 50) to yield daily concentration averages (midnight-to-midnight local standard time).

Meteorological: Horizontal wind speed, wind direction, temperature, barometric pressure, and precipitation will be continuously monitored to yield 15-minute averages and totals of these parameters. The data will be processed into hourly averages and totals in the data management office. Data collection and processing will be in accordance with the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Version 2.0 (Final) US Environmental Protection Agency, EPA-454/B-08-002, March 2008* and the *Meteorological Monitoring Guidance for Regulatory Modeling Applications, U.S. Environmental Protection Agency, EPA-454/R-99-005, February 2000*. Where there is an inconsistency between the two documents that is not clarified in the QAPP, the newer guidance document will be used.

A6.1 Description of Work

The work to be performed for this program has been divided into five tasks, as detailed below.

1) Monitoring Equipment Selection and Procurement – MMA has selected and procured all instrumentation and support systems. Table A6-1 details the monitoring and support equipment used for the project. Prior to field deployment, MMA will test the meteorological and data acquisition instrumentation at its office. At the completion of testing, MMA will prepare the instrumentation for safe transport to the site for

installation. The monitoring systems will then be calibrated on site. The instrumentation may be run for several days to ensure they operate properly prior to the commencement of formal data collection.

Table A6-1: Project Instrumentation and Support Systems

Monitoring Parameters & Support Systems	Make	Model	Sample Height
Wind Speed	RM Young	05305 Wind Monitor-AQ	10 meters
Wind Direction	RM Young	05305 Wind Monitor-AQ	10 meters
Ambient Temperature	RM Young	41342VC	2 meters
Precipitation	RM Young	52022	~1 meter
Barometric Pressure	RM Young	61302V	~1.5 meters
PM_{10}	Met One	BAM-1020	2 meters
PM_{10}	Tisch	TE-6070DV-TP	2 meters
Data Acquisition System (Data Logger)	Campbell Scientific	CR1000	N/A
Cellular Digital Modem	To be determined	To be determined	N/A
Shelter, climate controlled	Shelter One	BX902B	N/A

2) Monitoring Site Selection – MMA worked with U.S. EPA Region V and Bear Run personnel to select appropriate monitoring sites that met U.S. EPA guidelines.

3) Monitoring Site Installation – Project personnel and MMA will arrange with local utilities to provide electrical power and cell phone service to the monitoring sites. MMA will install the monitoring instrumentation at the locations approved by U.S. EPA Region V in accordance with U.S. EPA guidelines and manufacturer's specifications. The systems will then be calibrated and checked for proper operation. The site operator will be trained by MMA to complete site and monthly flow checks.

4) Quality System – MMA prepared comprehensive quality assurance and quality control (QA/QC) documentation, including standard operating procedures (SOPs), forms, and the project specific Quality Assurance Project Plan (QAPP) that follows U.S. EPA guidelines. The QAPP is the primary reference for all site operations, QA/QC, and data processing. Project-specific SOPs and forms are provided in Appendix A. U.S. EPA guidance documents are listed in the Program References section.

5) Routine Operations – Site checks will be performed by the site operator weekly or every other week depending on the site. Flow checks of the particulate monitors will be completed monthly. FRM sampler field blanks will be collected monthly. MMA will download and review data from the monitoring stations at least three times a week, provide technical support to the site operator, initiate corrective actions to address any identified inconsistency, and perform any required remedial maintenance on all program monitoring instrumentation and support equipment. MMA will also perform maintenance and calibration visits as described in the QAPP. Data management follows procedures listed in the QAPP. All raw and validated data will be archived in a project-specific database on MMA's server and backed up for security. MMA will also prepare monthly data reports.

A6.2 Project Measurements

A summary table listing the parameters that will be monitored at the Bear Run air quality monitoring station is presented in Table A6-2 below.

A6.3 Assessment Requirements

Meteorological data and FEM particulate data collected by the BAMs will be downloaded and reviewed at least three times a week. FRM samples will be collected on a one-in-six day frequency following the U.S. EPA National Ambient Particulate Monitoring Schedule. This schedule is presented in Appendix B. The site operator will complete site checks at least weekly or every other week depending on the site. On a monthly basis, the site operator will complete monthly flow checks of the particulate monitors. Meteorological instrumentation and particulate samplers will be calibrated at the start of the monitoring program. An MMA air monitoring specialist will travel to the site near the midpoint of the four-month sampling program to complete maintenance and calibration of the FRM particulate monitor.

Table A6-2: Bear Run Monitoring Project Sampling Specifications

Parameter	**Units and Range**	**Sampling Frequency**
Wind Speed	0 - 90 mph	1 second
Wind Direction	0 - 360°	1 second
Ambient Temperature (at 2 Meters)	-50 to +50°C	1 second
Precipitation	>2 inches per hour	1 second
Barometric Pressure	500 - 1100 hPa	1 second
Particulate Matter with an Aerodynamic Diameter of 10 Microns (µ) or Less (PM_{10}) by FEM	0 - 1.000 mg/m^3	Continuous (measurement cycle is 50 minutes)
Particulate Matter with an Aerodynamic Diameter of 10 Microns (µ) or Less (PM_{10}) by FRM	0 - 300+ µg/std. m^3	Integrated 24-hour sample, midnight-to-midnight every 6^{th} day

Performance audits of the PM_{10} samplers will be completed within 15 days of project startup, near the midpoint of the four-month sampling program, and within 15 days of project shutdown. Performance audits of the meteorological instrumentation will be completed within 15 days of project startup and within 15 days of project shutdown. (Note: Typically, the particulate sampler and monitors are audited quarterly and the meteorological sensors audited every six months.) A formal audit report will be produced after each performance audit.

Any monitoring inconsistency will initiate immediate corrective action. The problem will be assessed and possible solutions identified. Some issues can be resolved by the site operator while others may require an emergency visit by an MMA air monitoring specialist.

A6.4 Schedule

The Bear Creek air quality monitoring schedule is presented below.

Table A6-3: Bear Run Monitoring Program Schedule

Task Description	**Date/Frequency**	**Comments**
Development of Monitoring Plan SOPs and QA/QC	May 2012	Submit to U.S. EPA by June 1, 2012
Procurement, Testing & Assembly	May - June 2012	
Installation, Startup, Initial Calibrations & Training	Early June 2012	Includes training of on-site operator
Initiation of Monitoring	By June 15, 2012	Begin data collection
Operations & Maintenance	June - October, 2012	Calibrations: PM_{10} Samplers- At startup and midpoint of sampling program Meteorological Instrumentation – At startup
	3x/Week	Data download & review
	By August 5, 2012	First monthly data report
	Monthly	Flow checks of PM_{10} samplers FRM sampler field blank
Quality Assurance	By June 30, 2012	Start up performance audits
	Program midpoint	PM_{10} performance audits
	Within 15 days of shutdown	Shutdown audits

A6.5 Reporting Requirements

The project reports are summarized in Table A6-4 below.

Table A6-4: Bear Run Monitoring Program Reports

Reports	Frequency	Content	Responsible Position/Individual	Distribution
Performance Audit Reports	At startup, program midpoint, and program shutdown	Accuracy Assessment Summary	James Kuenning QA Manager	See Section A3, Distribution List
Data Reports	Monthly	Summary tables of data collected, calibration and audit results, precision data	Ray Roetman Air Monitoring Project Manager	See Section A3, Distribution List

Note: Due to the nature and anticipated length of the sampling program, a technical system audit and report are not applicable and will not be completed.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MONITORING DATA

A7.1 Data Quality Objectives

As stated in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Version 2.0 (Final) US Environmental Protection Agency, EPA-454/B-08-002, March 2008*, the data recovery objective for meteorological parameters is 90 percent (%). Consistent with the guidance presented in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, US Environmental Protection Agency, EPA-454/B-08-003* data completeness will be 75% for particulate sample collection.

A7.2 Criteria for Measurement Data

Meteorological monitoring accuracy and resolution parameters will be consistent with *Meteorological Monitoring Guidance for Regulatory Modeling Applications, US Environmental Protection Agency, EPA-454/R-99-005, February 2000* and the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Version 2.0 (Final) US Environmental Protection Agency, EPA-454/B-08-002, March 2008*.

Measurement quality objectives, accuracy, and resolution parameters for particulate monitoring will be consistent with Volume 2.11 of the *Quality Assurance Handbook for Air Pollution Measurement Systems* and the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, US Environmental Protection Agency, EPA-454/B-08-003, December 2008.*

A7.2.1 Measured Parameters

Each parameter will have specific measurement performance criteria. These requirements are summarized in Table A7-1.

A7.2.2 Data Collection System

The particulate monitors have an internal data logger that captures concentration and operation status information. Data and information on the particulate monitor's internal data logger will be downloaded using a cellular modem, cellular telephone, and supporting software.

All meteorological data will be captured on-site by a data acquisition system (DAS). The project-specific meteorological DAS will consist of a data logger, cellular modem, cellular telephone, and supporting software. The DAS will provide a remote link to the site for data and documentation collection and operational status assessment.

Table A7-1: Measurement Quality Objectives and Performance Requirements

Parameter	Make	Model	Specified Accuracy	EPA Required Accuracy	EPA Required Resolution	Quarterly Data Completeness
Wind Speed	RM Young	05305 Wind Monitor-AQ	±0.2 m/s	±(0.2 m/s + 5% of observed)	0.1 m/s	90%
Wind Direction	RM Young	05305 Wind Monitor-AQ	±3°	±5°	1.0°	90%
Ambient Temperature	RM Young	41342VC	±0.3°C	±0.5°C	0.1°C	90%
Precipitation	RM Young	52022	2% up to 25 mm/hr, 3% up to 50 mm/hr	±10% of observed or ±0.5 mm	0.3 mm	90%
Barometric Pressure	RM Young	61302V	0.03 kPa (-40 to +60°C)	±0.3 kPa	0.05 kPa	90%
PM_{10} FEM	Met One	BAM-1020	±2 μg/m^3 (24 hours)	±10%	1 μg/m^3	75%
PM_{10} FRM	Tisch	TE-6070DV-TP	±2 μg/m^3 (24 hours)	±10%	1 μg/m^3	75%

A7.3 Data Quality Indicators

A7.3.1 Continuous Particulate Monitors

Precision: Flow checks of the PM_{10} sampler and monitors will be completed monthly. Precision is measured indirectly by assessing how the flow rate indicated by the monitor compares to the flow rate measured by a certified flow rate measurement device.

Accuracy: The accuracy of particulate monitors is determined by performance audits. Performance audits will be completed in accordance with Procedure P9002BR contained in Appendix A. Instrument specific accuracies are listed in Table A7-1.

A7.3.2 Meteorological Sensors

Precision: Measuring the precision of meteorological sensors is not applicable, as this data quality indicator is not required to be assessed by U.S. EPA.

Accuracy: The accuracy of meteorological sensors is determined by performance audits. Performance audits will be completed in accordance with Procedure P9002BR contained in Appendix A. Instrument specific accuracies are listed in Table A7-1.

A8 SPECIAL TRAINING REQUIREMENTS AND CERTIFICATIONS

The site operators will be trained by the air monitoring contractor in the day-to-day operation of the monitoring stations. Proper in-house training is assured by using trainers who are knowledgeable and experienced in ambient air quality monitoring. Documentation used for training includes the project-specific QAPP and instrument manuals. The training will be in-house, so no certification is available. Site operator tasks include

- site checks,
- routine maintenance of the PM_{10} FEM and FRM instruments,
- flow checks of the PM_{10} FEM and FRM instruments, and
- collection of field blanks for the PM_{10} FRM instrument.

Data analysts are trained by the data manager or a designated alternate. Data analysts are trained to use in-house computer programs to process data into report format. Data analysts are also trained to complete QC checks of the raw and processed data. Professional certifications for data analysts are not required.

Air monitoring contractor staff working on-site for the project are experienced in ambient air monitoring systems. These staff members have training in CPR, first aid, and fall protection. The certifications are kept current, and the documentation is stored in the air monitoring contractor’s personnel files. All personnel must annually complete the PMM site-specific safety training.

A9 DOCUMENTS AND RECORDS

The following reports will be prepared over the program duration.

Table A9-1: Program Reports

Monthly Data Reports	Emailed to U.S. EPA within 21 days of the end of the monitoring month
Performance Audit Reports	At startup, program midpoint, and program shutdown

A monthly data report will be available for submission to U.S. EPA Region V within 21 days of the end of the monitoring month. The reports will be submitted via electronic media in Adobe Reader (PDF) format.

The monthly data report will include a narrative summary of the pertinent aspects of monitoring operations and the air quality data collected during the monitoring month, as well as the following:

1. A listing of all individual hourly meteorological data values.
2. A listing of the daily average PM_{10} concentrations for the period midnight-to-midnight local standard time, as per 40 CFR 58.13(d).
3. Monthly mean statistics for wind speed, temperature, and barometric pressure data.
4. The first and second highest 24-hour concentrations for PM_{10}.
5. Documentation of the PM_{10} sampler calibrations completed during the month, including the current Certificate of Calibration for the flow rate certification device used.
6. A summary of data collection efficiency rates (completeness) for each parameter and a discussion of any missing data with resulting corrective actions taken.
7. A summary of audit results for all parameters.

Validated data will be submitted to U.S. EPA Region V via electronic media in MS Excel or ASCII format. Hourly data values for each meteorological parameter and 24-hour (midnight-to-midnight local standard time) average PM_{10} concentrations will be included in the electronic monthly report.

All hardcopy records, digital data, and other project related monitoring documents will reside at the MMA office in Englewood, Colorado for a minimum of two years. PM_{10} filter samples will be retained for two years beyond the sampling date.

B DATA GENERATION AND ACQUISITION

B1 SAMPLING PROCESS

The purpose of the air quality monitoring program is to address the U.S. EPA Region V Section 114(a) request of November 2011. Air quality and meteorological data will be collected at the sampling location in the project area depicted in Figure A5-1.

Continuous PM_{10} will be measured with Met One Model 1020, AC-powered beta attenuation monitors (BAMs) that are U.S. EPA certified as an equivalent measurement for PM_{10}. A collocated FRM ambient particulate sampler at the southeast downwind site (Site #1) will collect PM_{10} samples on a 24-hour integrated basis from midnight to midnight local standard time every sixth day on the U.S. EPA National Ambient Particulate Monitoring Schedule, which is provided in Appendix B. The BAMs collect hourly average concentration data from which 24-hour average concentrations will be calculated for the period from midnight to midnight Central Standard Time (CST). Inlets for the BAM and FRM samplers will be located approximately two meters above ground level.

The meteorological parameters of horizontal wind speed and wind direction will be measured continuously at the ten-meter level on an open-lattice meteorological tower. Temperature will be measured continuously at the two-meter level of the tower. The temperature sensor will be housed in a fan-aspirated radiation shield. The barometric pressure sensor will be located in the data logger enclosure. A precipitation gauge will be installed with the inlet at approximately one meter above ground level.

RM Young (wind speed, wind direction, temperature, barometric pressure, and precipitation) and Campbell Scientific, Inc. (data logger) manufacture the meteorological instruments. All of the sensors meet PSD requirements. Each instrument produces a signal that is fed to the data acquisition system, digitized, converted to engineering units, and stored in electronic memory.

The meteorological tower and air monitors will be located where the effects of obstructions, such as trees, buildings, etc., are minimized.

The southernmost site (#1) is located just off SR159 on an abandoned lot now owned by PMM. As referenced on the attached map, this proposed monitoring site is immediately adjacent to several homes. One such residence is approximately 100 feet north of the selected monitoring site. This site is 1300 feet southeast of the active pit and represents the closest practical location to those mining operations. Both an FEM monitor and an FRM sampler will be located at this site.

The location selected for Site #2 is roughly 2500 feet northeast of the active pit. This location is very well suited to measure concentrations from the strong southerly and southwesterly wind components shown in the Lawrenceville wind rose.

An upwind site (#3) is located on property controlled by PMM that sits approximately four miles west-northwest of the active pit. This site is well exposed to characterize background concentrations upwind of the PMM property. It also offers an excellent location for the requisite 10-meter meteorological tower.

U.S. EPA Region V staff approved the locations of the monitoring sites in a conference call with PMM on April 23, 2012.

Photographs from the sites looking toward the four cardinal directions are shown in Figures B1-1 through B1-3.

Looking North

Looking South

Looking East

Looking West

Figure B1-1: Air Station 1 - Looking Away from the Site in Each of the Four Cardinal Directions

Looking North

Looking South

Looking East

Looking West

Figure B1-2: Air Station 2 - Looking Away from the Site in Each of the Four Cardinal Directions

Looking North

Looking South

Looking East

Looking West

Figure B1-3: Air Station 3 – Looking Away from the Site in Each of the Four Cardinal Directions

B2 SAMPLING AND REFERENCE METHODS

The sampling method for each parameter is summarized below.

Table B2-1: Sampling Methods

Measured Parameter	Measurement Method
Wind Speed	AC sine wave with a frequency proportional to wind speed
Wind Direction	Precision wire-wound potentiometer
Ambient Temperature	1000 ohm platinum RTD
Precipitation	Tipping bucket
Barometric Pressure	Solid-state transducer electronic sensor
PM_{10} FEM	Beta attenuation
PM_{10} FRM	Gravimetric analysis

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The reference method for each parameter is listed below.

Table B2-2: Reference Methods

Parameter	Manufacturer	Model	Reference Method	EPA Required Accuracy
Wind Speed	RM Young	05305 AQ	NA	±(0.2 m/s +5% of observed)
Wind Direction	RM Young	05305 AQ	NA	±5°
Ambient Temperature	RM Young	41342VC	NA	±0.5°C
Precipitation	RM Young	52022	NA	±10% of observed or ±0.5 mm
Barometric Pressure	RM Young	61302V	NA	±0.3 kPa
PM_{10} FEM	Met One	BAM-1020	EPQM-0798-122	±10% (flow)
PM_{10} FRM	Tisch	TE-6070DV-TP	RFPS-0202-141	±10% (flow)

B3 SAMPLE HANDLING AND CUSTODY

Sample Handling

Sample collection procedures for PM_{10} samples are provided in the standard operating procedure (SOP) titled “PM_{10} Particulate Sampler Operation and Particulate Collection Procedure (for Tisch Volumetric-Flow-Controlled Samplers)” provided in Appendix A.

One PM_{10} field blank will be collected per month for the FRM sampler. Field blanks are collected to determine the extent of any changes in filter weight due to filter handling or shipment procedures. The field blank procedure is detailed in the SOP listed above.

Chain-of-Custody Procedures

A Chain-of-Custody (COC) record will be completed for all PM_{10} sample shipments. The COC form will be initiated by the field technician collecting the data and included with each shipment to the laboratory. The form identifies the sample collection date, the name and signature of the field technician, and the date of sample shipment. The sample (filter) number will be listed on the COC form. Once the samples are received by the laboratory, the COC form will be signed and dated. The COC form will be signed by all personnel handling the samples in order to trace a sequence of events. Shipping company air bills may be attached to the COC to provide further information on the sequence of events. An example COC form is provided in Appendix A.

Samples will be shipped from Bear Run to the laboratory via a delivery service using a tracking number.

Sample Preservation Methods and Maximum Holding Times

Each PM_{10} filter will be folded in half, placed in a file folder, and enclosed in a re-sealable plastic bag. The filters, a Sample Data Sheet for each filter, and a COC form will be shipped in a rigid cardboard box to maintain the integrity of the filter samples.

Laboratory filter handling procedures are provided in Appendix A. After gravimetric analysis, particulate filters will be kept for a minimum of two years at the office of PMM or their air monitoring contractor.

Sample preservation and holding times are not applicable for any other parameters measured for this project.

B4 ANALYTICAL METHODS

This section refers to the analytical methods required for the gravimetric analysis of particulate filters. The SOPs for the air monitoring laboratory are provided in Appendix A.

Gravimetric analysis of FRM PM_{10} filters will be performed by qualified laboratory personnel. Quality assurance analysis will be performed by a qualified laboratory employee different from the person who performed the primary analysis. Laboratory turn-around time for PM_{10} filter analysis is two weeks after receipt.

The laboratory equipment used for PM_{10} analysis for this project is listed below.

Table B4-1: Laboratory Equipment for PM_{10} Analysis

Equipment	Model	Serial Number
Sartorius Balance	LA130SF	22514149
Dickson Hygrothermograph	THDX	8254370
Filter Desiccation Chamber	NA	NA
Bemis Water Wick Humidifier	6974	NA

The balance is serviced and calibrated annually by an independent company using weight sets traceable to the National Institute for Standards and Technology (NIST). The Dickson hygrothermograph temperature and relative humidity sensors are certified every six months using standards traceable to NIST.

One FRM PM_{10} sampler field blank per month will be analyzed by the laboratory. A field blank filter is handled exactly the same as a true sample, except that no air is drawn through the filter.

As stated in the Laboratory Procedures for Gravimetric Analysis and Handling of Air Monitoring Particulate Filters (Appendix A), accuracy of the balance is verified whenever a set of samples is weighed. Two ASTM-1 (formerly named "class S") standard weights covering the weight range normally encountered in weighing filters are to be used in establishing accuracy. If one or more of the standard weights cannot be measured within 0.0005 grams of its stated value, the balance will be recalibrated. The manufacturer or their qualified representative will perform the calibration and subsequent adjustments. In addition, the balance was calibrated when first purchased, yearly thereafter, and at any time it has been moved or subjected to rough handling. Results of all balance checks and calibrations are stored at the laboratory. The method detection limit is 0.1 milligrams (mg) per filter.

B5 QUALITY CONTROL REQUIREMENTS

Particulate Monitors

The continuous particulate monitors will be acceptance tested prior to sample collection. Subsequent to installation, monitors will be calibrated using a calibration device with a NIST-traceable certification. Calibration of the monitor's flow establishes the traceability of the field measurement to a primary standard. Calibrations of the monitors will be conducted according to an established schedule in order to maintain the viability of the data. Calibrations will occur at project startup, near the midpoint of the four-month sampling program, and after maintenance or repair of the flow control device. Calibrations of the PM_{10} monitors will be completed if the measured flow deviates by ±7 percent from the audit value (as per U.S. EPA *Quality Assurance Handbook, Volume II Part II, 2.11.2.0*). Detailed calibration procedures for these monitors are provided in Appendix A. The flow rate, temperature, and barometric pressure for the BAM FEM monitors will be checked monthly using a calibration device with a NIST-traceable certification.

Meteorological Sensors

The meteorological sensors are factory calibrated. Upon receipt, the sensors will be acceptance tested and calibrated in the MMA office prior to field installation. Subsequent to installation, the meteorological sensors will be calibrated using standards with current NIST-traceable certifications, where applicable. Calibrations of the meteorological sensors are conducted according to an established schedule in order to maintain the viability of the data. Calibrations will occur at the start of the monitoring program and after maintenance, repair, or an unsatisfactory audit result. Detailed procedures and forms for meteorological sensor calibrations are provided in Appendix A.

Site checks, which include assessment of the particulate monitors and meteorological sensors, will be completed every week to two weeks depending on the site. Particulate data, meteorological data, and diagnostic information retrieved from the site will be inspected three times a week by a data analyst in the MMA office.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

B6.1 Inspection and Acceptance Testing

Upon receipt of the monitoring instrumentation and equipment, acceptance testing will be performed. The shipping boxes will be inspected for damage. The box contents will be compared to the packing slip to ensure that the equipment list is complete and all parts are undamaged. When possible, instrumentation will be acceptance tested by performing an initial calibration at the MMA office on each instrument or sensor. If the instruments cannot be calibrated properly, the instrumentation manufacturer is contacted to identify and repair the problem. The acceptance testing procedures are documented on the appropriate calibration forms (see Appendix A).

B6.2 Preventive and Corrective Maintenance

Preventive maintenance is a prescribed set of routinely scheduled procedures to ensure the proper operation of equipment and instrumentation. Specific maintenance and inspection procedures are provided in the various instrument instruction and operational manuals. The procedures and schedule for preventive maintenance recommended by the manufacturers are followed for this monitoring program. Prior to preventive maintenance, an "as-found" calibration will be completed, if possible. Preventive maintenance and corrective work will be completed and noted on the calibration form. An "as-left" calibration will be completed immediately subsequent to any preventive maintenance or repair.

A summary of spare parts for each monitoring instrument is provided in the table below.

Table B6-1: Spare Parts Inventory

Instrument	Spare Parts
Wind Speed Sensor	Bearings, propeller
Wind Direction Sensor	Bearings, potentiometer
PM_{10} FEM Monitors	Pump, o-rings, filter tape
PM_{10} FRM Sampler	Motor brushes, silicone spray

As the monitoring program is anticipated to last four months, maintenance of the meteorological sensors is not anticipated.

Filter tape will be replaced approximately every six weeks on the BAMs. Motor brushes on the FRM PM_{10} sampler will be replaced near the midpoint of the four-month sampling program. The FRM sampler and BAM PM_{10} inlets will be cleaned at least once every three months. As the monitoring program is anticipated to last four months, other maintenance on the particulate samplers is not anticipated.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

Calibration procedures are performed to assure the quality of the data generated from the monitoring systems and the support instrumentation. There are two types of calibration procedures: unadjusted and adjusted. The unadjusted calibration is a benchmark for the quality of the preceding data. (Note: An unadjusted calibration may not be possible if the monitoring system has failed and is non-operational.) If any adjustments and/or repairs were made, an adjusted calibration, which becomes a benchmark for the quality of future data, must be successfully performed prior to resuming data collection. Calibration procedures to be followed and forms to be used are included in Appendix A.

Calibration Frequency

The initial calibration of the particulate monitors, meteorological sensors, and data logger will be performed on site, prior to initiating data collection. Subsequent calibrations of each particulate monitor will be near the midpoint of the four-month sampling program and after maintenance or repair of the flow control device. Additional calibrations of each meteorological sensor will be completed after any maintenance or adjustment.

Certification of Calibration Standards and Certification Records

Test instrumentation used to calibrate the particulate monitors and meteorological sensors are certified yearly using standards traceable to the National Institute of Standards & Technology (NIST) where possible (Table B7-1). Original certification documents are kept in the office files of the air monitoring contractor.

Table B7-1: Specified Calibration Standards

Parameters	Calibration Standard
PM_{10} FEM Monitors	deltaCal (for flow, BP, and temperature)
PM_{10} FRM Sampler	Variable orifice or HiVolCal
Wind Speed	Anemometer drive and/or synchronous motors
Wind Direction	Precision compass
Ambient Temperature	Digital thermometer
Precipitation	Class A pipette
Barometric Pressure	Certified altimeter or hand-held barometric pressure sensor

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

For the particulate monitors and meteorological sensors, spare parts (see Table B6-1) will be purchased from the manufacturer of the instrumentation. Generic spare parts typically are not accepted. The spare parts will be inspected for shipping damage upon receipt. Maintenance items and replacement parts will be kept primarily on site. Some items may be kept at the air contractor's office. If necessary, other parts will be ordered directly from the instrument manufacturer using overnight shipping to minimize down time.

Since instrument calibrations are required following the installation of any spare parts, the use of any spare parts will be documented on the calibration form. The air monitoring data manager or their designee will be responsible for the acquisition and installation of spare parts.

For the continuous particulate samplers, the main consumable is filter tape. Each roll of filter tape lasts approximately six weeks. A five-month supply of filter tape was purchased with the instruments. The rolls of filter tape will be stored on site.

Meteorological consumables are not expected to be needed during this monitoring program; typically, bearings in wind sensors are replaced yearly and potentiometers in wind direction sensors are replaced every two to three years. An inventory of bearings and potentiometers is maintained at the air contractor's office.

B9 NON-DIRECT MEASUREMENTS

This section does not pertain to this project as all particulate and meteorological measurements are direct.

B10 DATA MANAGEMENT

Data Management Process

The project meteorological data logger will be automatically polled daily by a computer at the air monitoring contractor's office. The internal data logger for each BAM will be polled manually or automatically at least three times per week by the air monitoring contractor's office. Data collected by the data logger since the previous download will then be transferred to the computer. The raw data files will be electronically stored in a file directory as raw data.

The particulate and meteorological data will be reviewed three times per week to determine if the data is representative and complete. The findings will be noted on the appropriate Monthly Data Review Logs, which are presented in Appendix A.

The data will then be processed by computer using a combination of in-house and commercial software programs. Data for each parameter will be processed appropriately (e.g., averaged, totaled, etc.). During processing, data for each parameter will be screened to see if the values are within the acceptable ranges. The screening criteria for meteorological data are based on Table 8-4 of EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*.

Data will be edited to note calibrations, audits, and missing data, as necessary. The data will then be reviewed by an individual different than the one who processed the data. The data and processing steps are documented using a Meteorological Data Processing Log form.

Problems noted by the reviewer of the raw data, values noted by the computer processing program as being outside the acceptable ranges, and issues noted by the data reviewer will be investigated immediately and the appropriate corrective action taken (e.g., instrumentation repaired, data flagged or invalidated, etc.). The air quality data manager will be consulted as necessary.

Data Storage

Once all reviews have been completed and all data issues resolved, data will then be reported and available for use in modeling. Electronic and hard copies of the data will be stored in the office of the air monitoring contractor. Electronic data will be backed up and stored at a location away from the office.

Data Handling Equipment and Procedures

The particulate and meteorological data will be collected, processed, and stored on a personal computer. Data storage media may include CD, DVD, compact flash memory card, removable hard drive, or other current or future storage devices. All site and air contractor computers have installed Windows 2000 or higher, which is adequate for the data handling needs of this project.

Meteorological data will be processed using a combination of in-house and commercial software.

C ASSESSMENT AND OVERSIGHT

This section describes the activities to assess the operational and data quality aspects of the air and meteorological monitoring program.

C1 ASSESSMENTS AND RESPONSE ACTIONS

C1.1 Routine Office Assessments

System operation, data quality, and data completeness will be assessed three times per week when the particulate and meteorological data are reviewed for representativeness and completeness. Assessment of the data will occur during data processing where each data value is screened to see if the values are within the acceptable ranges.

C1.2 Site Visits

The monitoring sites will be visited every week to two weeks, depending on the site. Site checks will be completed during each site visit. Flow rate, temperature, and barometric pressure will be checked monthly on each BAM.

C1.3 Instrument Calibrations

The initial field calibration of the particulate monitors, meteorological sensors, and data logger will be performed prior to the initiation of data collection. Subsequent calibrations of each particulate monitor will be completed near the midpoint of the four-month sampling program and after any maintenance or adjustment. Additional calibrations of each meteorological sensor will be completed after any maintenance or adjustment.

C1.4 Independent Performance Audits

An independent performance audit provides the monitoring program with a measure of quality assurance in that the personnel, instrumentation, equipment, and technical standards used to conduct the audit are independent of normal operations. The performance audits will be conducted in accordance with the following procedures that were developed using information contained in the *Quality Assurance Handbook for Air Pollution Measurement*

Systems, Volumes I, II, and IV. All performance audits will be performed using testing equipment with calibrations traceable to NIST where possible.

Independent performance audits will be conducted within 15 days of project startup and within 15 days of project shutdown. During the project, particulate monitors will also be audited near the midpoint of the four-month sampling program. The QA audit manager will conduct the independent performance audits (see Figure A4-1, Organization Chart). The audit report will be submitted to U.S. EPA within 21 days of completion of the performance audits. Performance audit SOPs and forms for each parameter are provided in Appendix A.

C2 REPORTS TO MANAGEMENT

Project reports consist of monthly data reports and performance audit reports. These reports will be submitted electronically in PDF format. Validated data will be submitted electronically in MS Excel or ASCII format.

Table C2-1: Bear Run Monitoring Program Reports to Management

Reports	Frequency	Content	Responsible Position/Individual	Distribution
Performance Audit Reports	At startup, program midpoint, and program shutdown	Accuracy Assessment Summary	James Kuenning QA Manager	See Section A3, Distribution List
Data Reports	Monthly	Summary tables of data collected., calibration and audit results, precision data	Ray Roetman Air Monitoring Project Manager	See Section A3, Distribution List

D DATA VALIDATION AND USABILITY

D1 DATA REVIEW AND VALIDATION

Data validation will follow U.S. EPA protocols. The data review and validation process is summarized below.

Downloaded particulate and meteorological data will be reviewed approximately three times per week. The review will be documented in the Bear Run Continuous PM_{10} Sampler Data Monthly Review Log and the Bear Run Meteorological Monitoring Program Monthly Data Review Log. These forms are contained in Appendix A.

The meteorological data will be processed and reviewed a second time. The data processing steps and reviews will be documented in the Meteorological Data Processing Log. If edits are made, a review of the data files will again be completed and documented on the Meteorological Data Processing Log. The data review and validation process is detailed in the Data Validation and Analysis procedure contained in Appendix A.

<u>Particulate Data Calculations</u>

Particulate monitoring accuracy calculations will be determined based on results from the audits. The percent difference between sampler flow and audit flow will be calculated using equations found on the audit and calibration worksheets. These worksheets are included in Appendix A.

Particulate monitoring precision statistics will be determined based on the collocated sampler data. The following will be calculated on a quarterly basis using guidance from 40 CFR 58, Appendix B, 7-1-05 edition.

- Percent difference
- Average percent difference
- Standard deviation
- Upper and lower 95% confidence intervals / probability limits

These calculations will only be performed when the PM_{10} collocated concentrations are above 15 µg/std.m^3. The calculations for the precision and accuracy of the particulate air quality parameters are below.

Percent difference:

- $d_i = \frac{Y_i - X_i}{(Y_i + X_i)/2} \times 100$

Where d_i is the percent difference, Y_i is the concentration measured from the collocated sampler, and X_i is the concentration measured from the primary sampler.

Average percent difference:

- $d_j = \frac{1}{n}\sum_{i=1}^{n} d_i$

Where d_j is the average percent difference, n is the number of collocated samples during the quarter, and d_i is the percent difference calculated above.

Standard deviation:

- $S_j = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n} d_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} d_i\right)^2\right]}$

Where S_j is the standard deviation, n is the number of collocated samples during the quarter, and d_i is the percent difference.

- Upper and lower 95% probability limits:

Upper 95 Percent Probability Limit $= d_j + \left(1.96 \times S_j / \sqrt{2}\right)$

Lower 95 Percent Probability Limit $= d_j - \left(1.96 \times S_j / \sqrt{2}\right)$

Where d_j is the average percent difference and S_j is the standard deviation.

D2 VALIDATION AND VERIFICATION METHODS

D2.1 Particulate Data

Data validation is the review process to screen data for anomalies and possible errors. Detailed data review, validation, and verification requirements will be in accordance with the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, US Environmental Protection Agency, EPA-454/B-08-003, December 2008*.

Validation criteria include the quality control elements of site checklists, calibrations (air quality parameters), air quality instrument precision checks, and independent performance audits completed during the monitoring period. Any air quality data that does not meet the criteria specified in the QAPP will be invalidated.

Data files will be downloaded at least three times per week into a specified file directory on the base computer hard drive. Two identical files will be stored, one into a raw data directory, which may not be edited, and one into a validated directory, which may be edited. The raw data directory serves as permanent record of all original monitoring data.

Initial data validation will consist of the following:

- Visual review of raw data.
- Initial screening of raw data for anomalies.
- Checking for flags.
- Verifying that data are in the expected range.

Intermediate data validation will consist of the following:

- Processing data and reviewing output logs for out-of-range data and data not meeting project-specified validation criteria.
- Entering validation codes for missing data, calibrations, audits, automatic QC checks, and manual QC checks.
- Verify that each hourly data value consists of 45 minutes or more of data.

Final data validation will consist of the following:

- Generating monthly data tables by parameter, which will be independently reviewed by a person not involved with the processing of the data set.
- Correction of the data set, if necessary, based on the independent review.
- Review of corrections by the independent reviewer.

D2.2 Meteorological Data

Data validation is the review process to screen data for anomalies and possible errors. Problems noted by the data processor, data values noted by the computer processing program as being outside the acceptable ranges (outliers), periods (of several hours or longer) where one or more parameters are nearly constant, or any other data validation issues noted will be investigated immediately. The data processing technician will examine the raw data for the 15-minute time periods, and if applicable, compare the site data to the regional data for the same time periods. The data processing technician will investigate whether maintenance, repairs, calibrations, or audits occurred during the time period of interest or whether any unusual activities were nearby that may have impacted data readings.

The air quality data manager will be consulted as necessary for a final determination of the data validity. The validation criterion for all monitoring data is that each hourly data average must represent at least 45 minutes of valid data.

The quality of the meteorological data will be validated based on the results of the initial acceptance tests and any independent performance audits or calibrations completed during the monitoring period.

Validation of data will be in accordance with Section 0 of the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Version 2.0 (Final), US Environmental Protection Agency, EPA-454/B-08-002, March 2008*.

D3 RECONCILIATION WITH USER REQUIREMENTS

This QAPP describes a study to characterize the air quality of the Bear Run Mine area. Procedures and requirements for monitoring equipment procurement, sampler siting, data collection, quality assurance and quality control, and reporting are described. Air quality data will be collected to characterize current conditions at the site. The procedures described herein will ensure that the project objectives are satisfied and the data collected are suitable per regulatory requirements. Data and statistical evaluations have been discussed in the applicable sections throughout the QAPP. Any data use limitations will be discussed in the monthly data reports.

Adhering to these QAPP procedures will ensure that the data will be of acceptable accuracy, precision, and completeness. Data collected are expected to provide a true representation of the air quality conditions that exist at the Bear Run Mine location and meet the project goals specified in Section A5.

PROGRAM REFERENCES

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, US Environmental Protection Agency, EPA-600/R-94/038a, April 1994.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, US Environmental Protection Agency, EPA-454/B-08-003, December 2008.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Part II, Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere (High-Volume PM_{10} Sampler Method), U.S. Environmental Protection Agency, September 1997.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Version 2.0 (Final) US Environmental Protection Agency, EPA-454/B-08-002, March 2008.

Meteorological Monitoring Guidance for Regulatory Modeling Applications, US Environmental Protection Agency, EPA-454/R-99-005, February 2000.

Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD), EPA-450/4-87-007, May 1987.

Model 05305 Wind Monitor-AQ Manual, Rev.080905, RM Young Company.

CR1000 Measurement and Control System Operator’s Manual, Campbell Scientific, Inc., 2009.

Model 41342VG/VF Platinum Temperature Probe Instruction Sheet, Rev. 09-97, RM Young Company.

Model 45302 Compact Aspirated Radiation Shield Manual, Rev. A062006, RM Young Company.

Model 61302V Barometric Pressure Sensor Instruction, Rev. F111109, RM Young Company.

Model 52202/52203 Tipping Bucket Rain Gauge Instruction Sheet, Rev. G062309, RM Young Company.

BAM-1020 Particulate Monitor Operation Manual, Revision H, 2008, Met One Instruments, Inc.

TE-6000 Series Particulate Matter 10 Microns and Less High Volume Air Sampler Operations Manual, Rev. A020199, Tisch Environmental, Inc.

Appendix A

Standard Operating Procedures and Forms

Appendix A-1

Meteorological Calibration Procedures and Forms

CALIBRATION PROCEDURE FOR A R. M. YOUNG WIND MONITOR

1.0 Introduction

Calibration of the R. M. Young Wind Monitor is to be performed at the initiation of monitoring and at subsequent six month intervals. Calibrations are also required immediately after any repair or replacement of the sensor or any of the system components.

The calibration procedure comprises the determination of pre-adjustment responses of the sensor to test values, maintenance, adjustment of the sensor's responses if warranted, documentation of the maintenance and adjustments, and recording of the sensor's responses after maintenance and adjustments.

Items required to calibrate a R. M. Young monitor are as follows:

1. R.M. Young anemometer drive or set of synchronous motors
2. R.M. Young Wind Monitor manual
3. Theodolite and/or compass
4. R.M. Young vane angle fixture

Begin the calibration by completing the top of the Wind Speed and Wind Direction Calibration Forms noting the date and time that the calibration begins.

1.1 System Inspection

Before determining the initial response of the R.M. Young Wind Monitor, inspect the signal cable, propeller, wind vane, and sensor bearings. Note observations in Section I of the appropriate calibration form.

2.0 Wind Speed Pre-adjustment Calibration Procedures

2.1 Preadjustment System Linearity Check

A system response check is performed by the use of an anemometer drive. The propeller is removed from the sensor of the wind speed shaft and the anemometer drive motor attached. The anemometer drive is turned on to the rpm values listed on the Wind Speed Calibration Form. The wind speed measured by the data logger reading for each rpm setting is recorded in Section II on the Wind Speed Calibration Form. Note if an anemometer drive is not available, a set of synchronous motors maybe used to turn the wind speed shaft at known rates of rotation.

2.2 Maintenance and Adjustments

At this point in the calibration, the technician should review the results of the linearity check and system inspection and determine what maintenance and adjustments are required, if any. Any necessary maintenance should be performed prior to any repairs and/or adjustment. For maintenance and adjustment procedures, consult the instrumentation manual or manufacturer.

2.3 Post-adjustment Checks

If adjustments or maintenance were performed, the steps listed in Section 2.1 of this procedure should be repeated and results recorded in Section IV of the Wind Speed Calibration Form. Evaluate the results of the post adjustment check. If the output values do not closely agree to expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the instrument response.

When the input calibration values produce acceptable responses, complete the calibration form noting the adjustments made, maintenance performed, and corrective action taken.

3.0 Wind Direction Pre-adjustment Calibration Procedures

3.1 Sensor Orientation

After the system is inspected, a check of the wind vane orientation is performed. The two methods for determining the wind direction (WD) sensor orientation are as follows:

Preferred Method (Theodolite/Solar Azimuth)

1) Locate the theodolite so that wind direction sensor is located in line between a landmark and the theodolite.

2) Level the theodolite. Using the telescope, sight the landmark and then the wind direction sensor. Move the theodolite until the wind direction sensor is in line with the landmark.

   The theodolite may have to be moved several times before the theodolite is correctly located. The calibration position for the theodolite should be marked by driving into the ground a large spike which has been spray painted with highly visible paint.

3) Using a solar azimuth angle table for the site latitude, site longitude, day and time, determine the azimuth of the sun at the time the sun is to be sighted. Set the horizontal degree circle to the azimuth of the sun for the time the sun is to be sighted and lock the horizontal degree circle to the telescope (upper half of theodolite). Unlock the horizontal degree wheel from the theodolite base. Rotate the telescope and sight the sun at the appropriate time. Lock the direction wheel to the theodolite base and unlock the direction wheel from the telescope (upper half of the theodolite).

4) Using the telescope, view the landmark. The value on the horizontal degree circle is the target azimuth.

5) Have an assistant point the vane at the landmark. Using the theodolite telescope, verify the vane is correctly lined up with the landmark. Record the wind direction, sine and cosine readings given by the data logger on the Wind Direction Calibration Form.

6) Have the assistant rotate the vane 180 degrees (^{o}), verify alignment and record the readings for wind direction, sine and cosine.

Alternative method (compass)

1) Using a high quality compass, site a landmark such that the WD sensor is directly in line with the landmark. Note the heading and correct for magnetic declination which can be obtained from the U.S. Geological Survey.

2) Have an assistant point the vane at landmark #1 and record the true azimuth (corrected for magnetic declination). Record the data logger readings for wind direction, sine and cosine on the Wind Direction Calibration Form.

3) Then have the assistant rotate vane clockwise (CW) 180° and site the vane at the landmark. Record readings.

3.2 System Linearity Check (Pre-adjustment)

The following procedure is the preferred and most accurate method of measuring and documenting linearity of the wind direction system. The procedure requires a R. M. Young tower mount vane angle fixture. If available, proceed as indicated below:

A) Carefully install calibration fixture on the sensor. Attach alignment arm assembly to the vane angle fixture.

B) Rotate fixture arm clockwise (CW) one full turn and set to the first target wind direction listed on the Wind Direction Calibration Form. Record the data logger reading for this point. Repeat for each of the target wind directions listed on the Wind Direction Calibration Form.

C) If all indications are in error by nearly the same amount, there may have been an error in the alignment of the calibration fixture. Readjust fixture and repeat test.

3.3 Maintenance and Adjustments

After all pre-adjustment checks and system inspections have been performed, the technician should review the results obtained and determine what maintenance and adjustments are needed, if any. Any necessary maintenance is to be completed prior to any potentiometer adjustments. For maintenance procedures, potentiometer locations and adjustment procedures, refer to the operation manual or contact the manufacturer for instructions. If the orientation is incorrect, adjust the wind direction sensor alignment.

3.4 Post-adjustment Checks

After all maintenance and adjustments have been made, the steps listed in Sections 3.1 and 3.2 should be repeated and results recorded in Section V and VI of the Wind Direction Calibration Form. Evaluate the results of the post-adjustment checks. If the output values do not agree with the expected values listed on Wind Direction Calibration Form, perform troubleshooting, maintenance, and adjustments as needed to correct the instrument response.

4.0 Conclusion

At the completion of the calibration, complete both calibration forms noting the adjustments made, maintenance performed, and corrective actions taken, if any. Note the time at which the calibration ended on the calibration forms.

WIND SPEED CALIBRATION FORM

(For a R.M. Young Wind Monitor)

	Manufacturer	Model No.	Serial No.
Sensor	R. M. Young		
Propeller			
Test Device			
Data Acquis.			

Project ____________________ Site ____________________

Date/Time ____________________ Technician ____________________

Sensor Height ________________ Starting Torque ______________

I. System Inspection

Cable ________ Propeller ________ Bearings __________ (Pass/Fail)

II. Pre-adjustment System Linearity Check

Test Device (rpm)	Target (mph)	Data Logger Reading (mph)
0		
300		
900		
1800		
3600		
5400		

III. Adjustments (If necessary)

1) If needed, perform cleaning and maintenance
2) Describe any cleaning, maintenance or adjustments performed in the comments section.
   New Starting Torque: ______________

IV. Post-adjustment System Linearity Check

Test Device (rpm)	Target (mph)	Data Logger Reading (mph)
0		
300		
900		
1800		
3600		
5400		

Comments:

WIND DIRECTION CALIBRATION FORM

For a R.M. Young Wind Monitor

Project ____________
Site ____________
Date/Time ____________
Technician ____________
Sensor Height ____________
Mag. Declination ____________

	Make	Model	Serial No.
Sensor	R.M. Young		
Compass			
Theodolite			
Data Logger			

I. System Inspection

Cable ________ Vane ________ Bearings ________ (Pass/Fail)

II. Sensor Orientation (Pre-adjustment)

Landmark ________ Theodolite Azimuth ________ Compass Azimuth ________ Compass Az. (Corrected) ________

Landmark ________ Theodolite Azimuth ________ Compass Azimuth ________ Compass Az. (Corrected) ________

Orientation (Deg.)	Azimuth (Degrees)	Data Logger Readings WD (Deg.)	(sine)	(cosine)
0 - 90				
90 - 180				
180 - 270				
270 - 360				

Agreement between target azimuth and system reading should be: $\pm 5°$

III. System Linearity Check (Pre-adjustment)

Degree Wheel (Degrees)	Data Logger Readings (Deg)	Degree Wheel (Degrees)	Data Logger Readings (Deg)
15		225	
45		270	
90		315	
135		345	
180			

IV. Adjustments (if necessary)

1) If needed, perform cleaning, maintenance, repairs, and/or adjustments.
2) Describe any cleaning, maintenance, repairs, or adjustments performed in the comments section.

V. System Linearity Check (Post-adjustment)

Degree Wheel (Degrees)	Data Logger Readings (Deg)	Degree Wheel (Degrees)	Data Logger Readings (Deg)
15	________	225	________
45	________	270	________
90	________	315	________
135	________	345	________
180	________		

VI. Sensor Orientation (Post-adjustment)

Landmark ____________ Theodolite Azimuth ________ Compass Azimuth ________ Compass Az. (Corrected) ________

Landmark ____________ Theodolite Azimuth ________ Compass Azimuth ________ Compass Az. (Corrected) ________

Orientation (Deg.)	Azimuth (Degrees)	Data Logger Readings WD (Deg.)	(sine)	(cosine)
0 - 90	________	________	________	________
90 - 180	________	________	________	________
180 - 270	________	________	________	________
270 - 360	________	________	________	________

Agreement between target azimuth and system reading should be: $\pm 5°$

Comments:

____
____
____

Site: ________________ Date: ________________

CALIBRATION PROCEDURE FOR A TEMPERATURE SENSOR

1.0 Introduction

Calibration of a temperature sensor is to be performed at the initiation of monitoring and at subsequent 6-month intervals. Calibrations are also necessary immediately after any repair or replacement of the probe or its components.

The calibration is comprised of the determination and documentation of the preadjustment responses of the temperature sensor to test inputs, adjustment of the sensor's responses, documentation of these adjustments and recording of the sensor's responses after adjustment.

Required test equipment for this calibration are the following:

1) Calibrated (NIST traceable) thermometer; resolution 0.01°C

2) Insulated liquid container

Start the calibration by completing the top of the Temperature Calibration Form.

1.1 System Inspection

Before determining the initial response of the temperature measurement system, inspect the sensor, signal cable, and radiation shield. If the radiation shield is fan aspirated, note whether the fan is working. Note observations on the Temperature Calibration Form.

2.0 System Response Check

If the temperature sensor is easily removed from the radiation shield and immersible, the system response check is performed by comparing the sensor response with that of an NIST traceable calibrated thermometer for at least three different temperatures. If the sensor is not immersible, a one-point calibration of the ambient temperature is done.

The temperatures selected for the calibration points ideally should encompass the range of the mean daily minimum temperature through the mean daily maximum temperature. Note that meteorological instrumentation may be located at remote sites. The means to make and transport suitable calibration baths and supplies to make such baths may be affected by availability of local line power and hot water or may be not be permitted due safety, DOT, and FAA regulations.

A. The process for liquid bath calibration points is listed below:

1) Set up the first liquid bath in an insulated liquid container.

2) Place the temperature sensor and calibration thermometer beside each other but not touching. Submerge the sensor and thermometer in the bath to the same depth.

3) Continuously agitate the bath.

4) When the readings of the thermometers have stabilized, take five concurrent readings, each one minute apart, of the calibration thermometer and the temperature value indicated by the data acquisition system. Ideally the data acquisition device should be set to one-minute averages and the readings of the calibration thermometer averaged over the same one minute periods. Record the readings on the Temperature Calibration Form.

5) Average the data acquisition system and calibration thermometer readings.

6) Repeat steps 1 through 5 for the second and third liquid baths.

B. The process for the ambient temperature calibration point is as follows:

1) Place the calibration thermometer at the same elevation and within one meter of a temperature sensor that has reached equilibrium with the ambient temperature. If possible, the person calibrating should stay downwind of the sensor and the calibration thermometer and keep the calibration thermometer out of direct sunlight.

2) After the calibration thermometer reaches equilibrium with the ambient temperature, take a minimum of five concurrent readings of the calibration thermometer and the data acquisition system, spaced one minute apart, and record the readings on the Temperature Calibration Form.

3) Average the readings for the data acquisition system and the calibration thermometer.

3.0 Maintenance and Adjustments

After all checks and system inspections have been performed, the results obtained should be reviewed to determine what maintenance and adjustments are needed, if any. Maintenance procedures are provided in the manufacturer's operation manual.

4.0 Postadjustment Calibration (if necessary)

If maintenance or adjustments were made, the steps listed in Section 1 and 2 should be repeated and results recorded on a new Temperature Calibration Form. Above the name of the form the word "postadjustment" should be written. Evaluate the results of the postadjustment calibration. If the output values do not agree with the target values, perform troubleshooting, maintenance and adjustments as needed to correct the instrument response.

5.0 Conclusion

When the instrument provides the proper response to the calibration input values, complete the calibration form noting the adjustments made, maintenance performed, and corrective action taken. Note the time at which the calibration ended on the calibration form.

TEMPERATURE CALIBRATION FORM

Project ______________________ Site ______________________
Date/Time ____________________ Technician __________________

	Manufacturer	Model No.	Serial No.
Sensor			
Data Acquisition			
Ref. Thermometer			

System Inspection: Cable ________ Sensor ________ Radiation Shield/Motor __________ (Pass/Fail)
List Weather Conditions (wind, sky cover) ______________________________________
Sensor Height ________________

Calibration Point:____

Reading	Time ( )	Data Acq. System (°)	Ref. Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

Calibration Point:____

Reading	Time ( )	Data Acq. System (°)	Ref. Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

Calibration Point:____

Reading	Time ( )	Data Acq. System (°)	Ref. Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

If needed, perform cleaning and maintenance. Describe any work performed
COMMENTS:

CALIBRATION PROCEDURE FOR A TIPPING BUCKET PRECIPITATION GAUGE

1.0 Introduction

Calibration of the tipping bucket precipitation gauge entails the determination of the preadjustment responses of the gauge to known input values, adjustment of the gauges responses, if warranted, documentation of the adjustment, and recording of the sensor's responses after adjustment.

Required test equipment for to conduct this calibration is as follows:

- A reference volume device (e.g. measuring pipet or burette).

Begin the calibration by completing the top of the Precipitation Gauge Calibration Form (F2139.1). Note the time and date that the calibration begins.

2.0 Preadjustment Checks

2.1 System Check

To complete the system check, first set the data logger data output interval to an appropriate time frame. For an interval with no precipitation or tips of the gauge bucket, check that the value output by the data logger is 0.00. Record results in Section I of the Precipitation Gauge Calibration Form. During the next time period, carefully remove the gauge cover. Slowly tip the two buckets a total of 25 times. Record the data logger output.

2.2 Gauge Check

A calibration is done by inputting to the precipitation gauge amounts of water known to an accuracy of at least 1 percent of the total to be used. Provide enough water to cause a minimum of 10 tips. Suggested devices for inputting a reference volume of water are a measuring pipette or burette, either a 10 milliliter (ml) size accurate to ±0.1 ml or a 25 milliliter (ml) size accurate to ±0.25 ml.

The sensor and signal check procedure is as follows:

1.) Slowly, drop by drop, let the water out of the reference volume device into the vary center of the precipitation gauge. At least 30 seconds should be allowed to fill one side of the tipping bucket.

2.) Allow enough drops of water to cause the bucket to tip 10 times, recording the amount of the water input per tip in Section II of the Precipitation Gauge Calibration Form.

3.) Compare the reference volume of water input to the target volume for 10 tips of the bucket. If the percent difference is greater than ±5, adjustments and/or maintenance are needed.

3.0 Maintenance and Adjustments

The precipitation gauge should now be inspected to see if the gauge is level and the funnels and tipping buckets are free of debris and dirt. If not, the gauge should be leveled and the funnels and tipping buckets cleaned. Record all actions on the Precipitation Gauge Calibration Form.

At this point in the calibration, the technician should review the results of the system and gauge checks and determine what maintenance and adjustments are required, if any. For any necessary maintenance, the instrumentation manual should be consulted for the proper procedure.

The procedure for adjusting the sensor (tipping buckets) is listed below:

1.) If at least six months of use has passed, place a small drop of light machine oil on each pivot bearing of the bucket assembly.

2.) Release the lock nuts on the cup adjustments.

3.) Move the adjustment screws down to a position that would place the bucket far out of calibration.

4.) Using a graduated cylinder, slowly pour into the upper bucket the exact amount of water that the manufacturer specifies will cause one tip.

5.) Turn the cup adjustment screw on the post on the opposite side up until the bucket assembly tips. Tighten the lock nut.

6.) Repeat steps 4 and 5 for the opposite bucket.

7.) Add water through the funnel, so that the buckets tip several times. Check that the amount of water needed to cause the bucket tips is within 5% of the target value to ensure that the bucket stops were adjusted correctly.

After adjustments are completed, replace the cover on the gauge.

4.0 Postadjustment Checks

Repeat the steps listed in Sections 2.1 and 2.2 of this procedure. Evaluate the results of the postadjustment checks. If the output values do not closely agree to expected values, perform trouble-shooting, maintenance and adjustments as needed to correct the instrument response.

When the instrument provides the proper response to the calibration input values, complete the Precipitation Gauge Calibration Form noting the adjustments made, maintenance performed and corrective actions taken. Note the time at which the calibration ended on the calibration form.

5.0 Conclusion

At the completion of the calibration, ensure that the precipitation gauge and data logger are returned to their normal operation and sampling configuration.

PRECIPITATION GAUGE CALIBRATION FORM

Project ______________________ **Date/Time** ______________________

Site ______________________ **Technician** ______________________

	Make	Model No.	Serial No.
Gauge			
Data Acquisition			

Reference Volume Device ____

Volume of water per tip ____________ **ml (B) per manufacturer specifications**

Each tip represents ________ **of precipitation**

I. Electronics Check (preadjustment)

Number of Tips	0	25	Comments or Additional Test
Target Data Logger Reading (H_20)			
Actual Data Logger Reading (H_20)			
Difference (H_20)			
Time Interval on Data Logger ( )			

Data Storage Location on Data Logger: ____________________

II. Gauge & System Check (preadjustment)

No. of Tips	1	2	3	4	5	6	7	8	9	10	Totals
Volume of Water											
Input per Tip (ml)											

Total: ________

$\dfrac{\text{\_\_\_\_\_\_\_\_\_\_}}{\text{10 tips}}$ **total H_2O volume (ml) =** __________ **ml H_2O/tip (A)**

$\% = \dfrac{A - B}{B} \times 100 =$ ________ %

Number of tips measured by data logger: ______

III. Maintenance and Adjustments (if necessary)

1. **Check that the precipitation gauge is level and clean.**
2. **Perform maintenance and adjustments as detailed in the manufacturer's operations manual**

IV. Electronics Check (postadjustment)

Number of Tips	**0**	**25**	Comments or Additional Test
Target Data Logger Reading (H_20)			
Actual Data Logger Reading (H_20)			
Difference (H_20)			
Time Interval on Data Logger ( )			

Data Storage Location on Data Logger: ____________________

V. Gauge & System Check (postadjustment)

No. of Tips	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Totals**
Volume of Water											
Input per Tip (ml)											

Total: __________

$\frac{\_\_\_\_\_\_\_\_}{\text{10 tips}}$ **total H_2O volume (ml) =** __________ **ml H_2O/tip (A)**

% = $\frac{A - B}{B}$ x 100 = __________ **%**

Number of tips measured by data logger: ______

Comments: ____

____

____

CALIBRATION PROCEDURE FOR A BAROMETRIC PRESSURE SENSOR AND MEASUREMENT SYSTEM

1.0 Introduction

Calibration of a barometric pressure sensor and measurement system is to be performed at the initiation of monitoring and at subsequent six-month intervals. Calibrations are also required immediately after any repair or replacement of the sensor or other system components.

The calibration comprises of the determination of the preadjustment (as found) responses compared to a collocated transfer standard (CTS), adjustment of the system's responses if warranted, documentation of these adjustments, and recording of the system's responses after adjustment.

For this calibration, the following test equipment is required:

1. Certified field altimeter or barometer.
2. Digital multimeter

To begin the calibration, complete the identifying information at the top of the Barometric Pressure Calibration Form.

2.0 System Inspection

Before determining the initial response of the barometric pressure system, inspect the signal cable and barometric pressure sensor. Record findings of condition in Section I of the Barometric Pressure Calibration Form.

3.0 Pre-Adjustment System Check

The system check of a barometric pressure measurement system requires a certified field altimeter or barometer to serve as a CTS. Set up the CTS as near as practical to the site barometric pressure sensor. Record concurrent values for the site barometric pressure sensor and CTS on the Barometric Pressure Calibration Form. Three sets of concurrent instantaneous readings, at different times of the day, from the site barometric pressure sensor and CTS should be taken.

Calculate the absolute difference and record results on Barometric Pressure Calibration Form. To complete the calibration satisfactorily, the measured site value should be within ±3 mb (±0.09 inches of Hg) of the corresponding certified field altimeter or barometer value.

4.0 Maintenance and Adjustments

At this point in the calibration, the technician should review the results of the system inspection and systems check to determine what maintenance and adjustments are required, if any. Any necessary maintenance should be performed prior to potentiometer adjustments. For maintenance procedures, potentiometer locations and adjustment procedures, consult the instrumentation manual or manufacturer.

5.0 Post-Adjustment Checks

If adjustments or maintenance were performed, the steps listed in Section 2.0 of this procedure should be repeated and results recorded in Section IV of the Barometric Pressure Calibration Form.. Evaluate the results of the post-adjustment checks. If the output values do not closely agree to expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the instrument response.

Note, if the site barometric pressure sensor cannot be calibrated satisfactorily, then the unit may have to be returned to the manufacturer to be checked out.

6.0 Conclusion

At the completion of the calibration, finish filling in the Barometric Pressure Calibration Form, noting the adjustments made, maintenance performed, and corrective actions taken, if any.

BAROMETRIC PRESSURE CALIBRATION FORM

Project ____________________ Site ______________________________
Date ______________________ Technician_________________________

	Manufacturer	Model No.	Serial No.
Site Sensor			
Data Acquis.			
Field Barometer			

Field Barometer Certification Date: _________________________________

Location of Sensor: ____

I. System Inspection: Cable ______________ Sensor ______________

II. Pre-adjustment System Check

TIME ( )	Data Logger Reading ( )	Field Cal. Device Reading ( )	Field Cal. Device Reading ( )	Difference ( )

III. Maintenance and Adjustments

1) If needed, complete maintenance, repairs and/or adjustments as per manufacturer's operation manual.
2) Describe any maintenance, repairs or adjustments in the Comments Section of the form.

IV. Post-adjustment System Check (if necessary)

TIME ( )	Data Logger Reading (of Hg)	Field Cal. Device Reading ( )	Field Cal. Device Reading ( )	Difference ( )

Comments:

Appendix A-2

Meteorological Audit Procedures and Forms

WIND SPEED AUDIT PROCEDURE

In conducting a wind speed audit, the performance audit general guidelines listed in P9002 are to be followed.

In order to complete a wind speed audit, a torque measurement device and an anemometer drive or set of synchronous motors are required. The wind speed measurement system should be tested by having the anemometer shaft turn at zero rpm and rates of rotation to produce a range of typical on-site ambient wind speeds from low to high.

The procedure using an anemometer drive is as follows (Note: a set of synchronous motors can be substituted for an anemometer drive):

1) Complete the information at the top of the Wind Speed Audit Form.

2) Remove the anemometer cups or propeller.

3) Holding the anemometer shaft still, record the data logger value for wind speed at zero rpm.

4) Attach to the anemometer shaft, an anemometer drive.

5) Set the rpm on the anemometer drive to obtain a low speed and turn the audit device on. Record the data logger reading for wind speed on the Wind Speed Audit Form.

6) Repeat step 5 and test the wind speed measurement system at a minimum of three other wind speeds spaced through the range of typical on-site ambient wind speeds.

7) Calculate the differences of the data logger readings to the audit test wind speed input and record on the Wind Speed Audit Form.

8) Measure the starting torque of the anemometer bearing assembly using a torque watch or other torque measurement device.

The sensor's digital response should agree with the synchronous motor input to within ±(0.5 mph + 5% of observed). The starting torque measured should be compared to manufacturer's listed torque value for the starting threshold. Measured torque values which exceed the manufacturer's listed torque value for the starting threshold indicate a problem such as the bearings in the wind speed are worn and need replacement.

WIND SPEED AUDIT FORM

	Manufacturer	Model	Serial No.
Sensor			
Cups/Propeller			
Data Logger			
Test Device			
Torque Watch			

Project ______________________

Site ______________________

Sensor Height ______________________

Date ______________________

Auditor ______________________

Reading ______________________

DYNAMIC WIND SPEED CHECK

(Using Synchronous Motors or an Anemometer Drive)

1) ____0____ RPM = __________ mph
2) __________ RPM = __________ mph
3) __________ RPM = __________ mph
4) __________ RPM = __________ mph
5) __________ RPM = __________ mph

	Test WS (mph)	Data Logger (mph)	Difference (mph)
1.			
2.			
3.			
4.			
5.			

Offline: ____________________ Online: ____________________

WIND DIRECTION AUDIT PROCEDURE

A wind direction (WD) audit must be completed following the performance audit guidelines listed in Procedure P9002. The process of auditing the wind direction sensor is described below:

I. AZIMUTH AUDIT

A. Preferred Method (Theodolite - Solar Azimuth)

1) Fill out the top portion of the Wind Direction Audit Form.

2) Locate the theodolite so the wind direction sensor is located in line between a landmark and the theodolite.

3) Level the theodolite. Using the telescope, sight the landmark and then the wind direction sensor. Move the theodolite until the wind direction sensor is in line with the landmark.

   The theodolite may have to be moved several times before the theodolite is correctly located. The audit position for the theodolite may be marked by driving into the ground a large spike which has been spray painted with highly visible paint.

4) Using a solar azimuth angle table for the site latitude, site longitude, day and time, determine the azimuth of the sun at the time the sun is to be sighted. Set the horizontal degree circle to the azimuth of the sun for the time the sun is to be sighted and lock the horizontal degree circle to the telescope (upper half of theodolite). Unlock the horizontal degree wheel from the theodolite base. Rotate the telescope and sight the sun at the appropriate time. Lock the direction wheel to the theodolite base and unlock the direction wheel from the telescope (upper half of the theodolite).

5) Using the telescope, view the landmark. The value on the horizontal degree circle is the target azimuth.

6) Have an assistant point the vane at the landmark. Using the theodolite telescope, verify the vane is correctly lined up with the landmark. Record the data logger values for wind direction, sine and cosine.

7) Have the assistant rotate the vane 180 degrees (^{o}), verify alignment and take another set of readings.

8) If a a second landmark is available, repeat steps 2 through 7 for. Ideally, the azimuth of the second landmark should differ by approximately 90^{o} from the first target.

B. Alternative Method (Compass – Solar Azimuth)

1) Fill out the top portion of the Wind Direction Audit Form.

2) Using a high quality compass, site a landmark with the WD sensor directly in line in site. Note the heading and correct for magnetic declination.

3) While the vane is pointed at landmark #1 and record the data logger values for wind direction, sine and cosine.

4) Then have the assistant rotate vane clockwise (CW) 180° and site the vane at the landmark. Take another set of readings.

5) Repeat steps 2 through 4 for a second landmark. Ideally, the azimuth of the second landmark should differ by approximately 90° or 270° from the first target.

To successfully pass the azimuth audit, the sensor must agree with the target (azimuth) reading by ±5°.

II. LINEARITY AUDIT

To complete this portion of the audit, the auditor must use the linearity fixture specifically made by the manufacturer for the particular make and model of wind direction sensor being audited.

A) Carefully install linearity fixture on the sensor.

B) Rotate fixture arm clockwise (CW) one full turn and set to the first target wind direction listed on the Wind Direction Calibration Form. Record the data logger reading for this point. Repeat for each of the target wind directions listed on the Wind Direction Calibration Form.

C) If all indications are in error by nearly the same amount, there may have been an error in the alignment of the linearity fixture. Readjust fixture and repeat test.

WIND DIRECTION AUDIT FORM

	Manufacturer/ Model No.	Serial No.		
Sensor	________	________	Project	________
Vane	________	________	Site	________
Digital Data Acq.	________	________	Sensor Height	________
Compass	________	________	Date	________
Theodolite	________	________	Auditor	________
Torque Watch	________	________	Reading	________

Solar Sighting: Time________ Azimuth________ Inclination________

Magnetic Declination: ________

Landmark #1 ________
Azimuth ________ °
Azimuth ________ °
(corrected)

Landmark #2 ________
Azimuth ________ °
Azimuth ________ °
(corrected)

Landmark #1				Landmark #2			
Target Azimuth (°)	Sensor-Data Acquisition System			Target Azimuth (°)	Sensor-Data Acquisition System		
	Azimuth (°)	Sine	Cosine		Azimuth (°)	Sine	Cosine

System Linearity Audit

Degree Wheel (Degrees)	Data Ac. System Readings (Deg)	Degree Wheel (Degrees)	Data Ac. System Readings (Deg)
15	________	225	________
45	________	270	________
90	________	315	________
135	________	345	________
180	________		

Offline: ________ Online: ________

TEMPERATURE SENSOR AUDIT PROCEDURE

A temperature audit is conducted using the general guidelines outlined in procedure P9002. The system temperature values should agree with the audit values to within ±0.5°C.

If the temperature sensor is easily removed from the radiation shield and immersible, the system response check is performed by comparing the sensor response with that of an NIST-traceable certified audit thermometer for at least three different temperatures. If not, a one-point audit of the ambient temperature is done.

The temperatures selected for the audit points ideally should encompass the range of the mean daily minimum temperature through the mean daily maximum temperature. Note that meteorological instrumentation may be located at remote sites. The means to make and transport suitable calibration baths and supplies to make such baths may be affected by availability of local line power and hot water or may be not be permitted due safety, DOT, and FAA regulations.

I. The process for water bath audit points is listed below:

1) Set up the first liquid bath in an insulated liquid container.

2) Place the temperature sensor and audit thermometer beside each other but not touching. Submerge the sensor and thermometer in the bath to the same depth.

3) Continuously agitate the bath.

4) When the readings of the thermometers have stabilized, take five concurrent readings, each one minute apart, of the audit thermometer and the temperature value indicated by the data acquisition system. Ideally, the data logger is either pre-programmed or set by the site operator to calculate to one-minute averages. The readings of the audit thermometer are averaged over the same one minute periods. Record the readings on the Temperature Audit Form.

5) Average the data acquisition system and audit thermometer readings.

6) Repeat steps 1 through 5 for the second and third liquid baths.

II. The process for the ambient temperature audit point is as follows:

1) Place the audit thermometer at the same elevation and within one meter of a temperature sensor that has reached equilibrium with the ambient temperature. If possible, the auditor should stay downwind of the sensor and the audit thermometer and keep the audit thermometer out of direct sunlight.

2) After the audit thermometer reaches equilibrium with the ambient temperature, take a minimum of five concurrent readings of the audit thermometer and the data acquisition system, spaced one minute apart, and record the readings on the Temperature Audit Form.

3) Average the readings for the data acquisition system and the audit thermometer.

TEMPERATURE AUDIT FORM

Project ______________________ Site ______________________
Date ______________________ Auditor ______________________

	Manufacturer	Model No.	Serial No.
Sensor			
Data Acquisition			
Audit Thermometer			

Sensor Height ______________

Audit Point: ____

Reading	Time	Data Acq. System (°)	Audit Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

Audit Point: ____

Reading	Time	Data Acq. System (°)	Audit Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

Audit Point: ____

Reading	Time	Data Acq. System (°)	Audit Thermometer (°)	Difference
1				
2				
3				
4				
5				
Average				(°)

COMMENTS:

Offline: ________________ Online: ________________

AUDIT PROCEDURE FOR A TIPPING BUCKET PRECIPITATION GAUGE

A precipitation audit is performed by inputting to the gauge amounts of water known to an accuracy of at least one percent of total to be used. Enough water should be provided to cause a minimum of ten tips. Suggested devices for inputting a reference volume of water are a Class A measuring Mohr pipette or burette, either ten milliliter (ml) accurate to 0.1 ml or 25 ml size accurate to 0.25 ml. The manufacturer's instrument manual lists the volume of water needed to tip the bucket once.

The audit procedure is as follows:

1. Fill in the information at the top of the Precipitation Gauge Audit Form.
2. Note the type of reference volume device (i.e., ten ml pipette, 25 ml burette, etc.) and fill the reference volume device to the top mark with water.
3. Slowly, drop-by-drop, let the water out of the reference volume device into the very center of the precipitation gauge.
4. Allow enough drops of water to cause the bucket to tip ten times, keeping track of the water input and number of tips.
5. Fill in water used and number of tips on the Precipitation Gauge Audit Form.
6. Compare these data to the precipitation amount noted by the event recorder and calculate the percent difference using the equation at the bottom of the Precipitation Gauge Audit Form.

NOTE: A calculation may be needed to equate the volume of water used to the deflection indicated on the recorder. If so, an equation should be provided in the instrument manual.

PRECIPITATION GAUGE AUDIT FORM

Project ______________________ **Date/Time** ______________________

Site ______________________ **Auditor** ______________________

	Make	Model No.	Serial No.
Gauge			
Data Acquisition			

Reference Volume Device ____

Volume of water per tip __________ **ml (B) per manufacturer specifications**

Each tip represents ________ **of precipitation**

Data Storage Location - CSI Data Logger *7 Channel No.: ________

Gauge & System Check (Trial 1)

No. of Tips	1	2	3	4	5	6	7	8	9	10	Totals
Volume of Water											
Input per Tip (ml)											

Total: ________

$\frac{\_\_\_\_\_\_\_\_}{\text{10 tips}}$ **total H_2O volume (ml) =** ________ **ml H_2O/tip (A)**

$\% = \frac{A - B}{B} \times 100 =$ ________ %

Number of tips measured by data logger: ______

Gauge & System Check (Trial 2, if needed)

No. of Tips	1	2	3	4	5	6	7	8	9	10	Totals
Volume of Water											
Input per Tip (ml)											

Total: ________

$\frac{\_\_\_\_\_\_\_\_}{\text{10 tips}}$ **total H_2O volume (ml) =** ________ **ml H_2O/tip (A)**

$\% = \frac{A - B}{B} \times 100 =$ ________ %

Number of tips measured by data logger: ______

Comments: ____

____

____

BAROMETRIC PRESSURE AUDIT PROCEDURE

Performance audits of the site barometric pressure sensor and data acquisition system will be performed using the general audit guidelines in Procedure P9002.

Performance audits on a barometric pressure measurement system require a certified audit field altimeter or barometer to serve as a collocated transfer standard (CTS). Set up the CTS as near as practical to the site barometric pressure sensor. Complete the top portion of Barometric Pressure Audit Form. Record concurrent values for the site barometric pressure sensor and CTS on the Barometric Pressure Audit Form. Three sets of concurrent instantaneous readings, at different times of the day, from the site barometric pressure sensor and CTS should be taken.

Calculate the absolute difference and record results on Barometric Pressure Audit Form.

To pass the audit, the measured site value should be within "3 mb ("0.09 inches of Hg) of the corresponding audit value.

BAROMETRIC PRESSURE AUDIT FORM

Project ______________________________ Site ______________________________
Date ________________________________ Auditor ___________________________

	Manufacturer	Model No.	Serial No.
Site Sensor	____________	____________	____________
Data Acquis.	____________	____________	____________
Audit Barometer	____________	____________	____________

Audit Barometer Certification Date: ______________________________

Location of Sensor: ____

General Weather Conditions: ____________________________________

System Inspection: Cable _____________ Sensor _____________

TIME ( )	Data Logger Reading (of Hg)	Field Audit Device		Difference ( )
		Reading ( )	Reading ( )	

Comments:

Appendix A-3

Standard Operating Procedures and Forms – FRM PM_{10} Sampler

PM_{10} PARTICULATE SAMPLER OPERATION AND PARTICULATE COLLECTION PROCEDURE (for Tisch Volumetric-Flow-Controlled Samplers)

1.0 General Procedure for Preparing Particulate Filters for Sampling Run

Inspect the clean, weighed, numbered filters received from the analytical laboratory to assure that the filters are not damaged or soiled prior to installation in the PM_{10} sampler. Damaged or soiled filters should be discarded and the number of the discarded filter noted on a separate Particulate Sample Data Form along with an explanation as to why the filter is being discarded. Filter cartridges available for this program should be used for sampling to allow for loading and unloading of the filters in an enclosed area. Filters to be used for the sampling run must be handled with either a flat-tipped tweezers or clean cotton gloves to avoid contamination with residual dirt or skin oil.

Note the number of the filter to be used on the Particulate Sample Data Form. Center the filter rough side up on the wire screen of the filter cartridge so that an airtight seal on the outer edge (1 cm) of the filter can be achieved. When aligned correctly, the edges of the filter will be parallel with the edges of the screen behind it and to the face plate gasket above it. Poorly aligned filters show uneven white borders around the filter after exposure. Tighten the two thumb screws on the cartridge to secure the filter. Place the cover of the cartridge over the filter until cartridge is installed on sampler. Cartridge is now ready to be placed on sampler.

2.0 Preparing Particulate Samplers for a Sampling Run

Loosen the size selective inlet (SSI) head bolts and allow the bolts to drop to the side before lifting the two stages of the SSI sampling head. Utilizing a filter cartridge prepared according to the instructions in Section 1.0 of this procedure, place the filter cartridge on the screen and tighten the thumb nuts evenly on alternate corners to properly align and seal the gasket. Remove the cover of the cartridge and lower the second stage of sampler over the filter cartridge. Check gasket for an adequate seal. Check bug screen to make sure it is clean. Check the collection shim surrounding the lower sampling tubes on the second stage for cleanliness. The shim should have a light coating of silicone to prevent "particle bounce". If the shim is dirty or requires silicone, loosen the two hold down clips and remove the shim. Wipe with a clean cloth and spray a light coating of silicone on the shim and replace. Procedures for determining whether the shim needs cleaning and the correct cleaning method are described in Section 4.1 of this procedure. If satisfied that shim is clean, lower first stage of sampler over second stage and bolt stage securely.

Check the gasket on the first stage for an adequate seal. If satisfied with the seal, tighten clamps on the side and bottom of the SSI head to the lower part of sampler.
Note on the Particulate Sample Data Form, the Site, Sampler Type and I.D. Complete the Installation section of the form.

Record on the back of a flow recorder circle chart the sampler type and ID, the sampling date, the elapsed time indicator reading, the particulate filter number and your initials. Install the chart.

Start the sampler and allow it to operate for a five minute period. After the five minute period, record the manometer value on the Particulate Sample Data Form. Turn the sampler off. The manometer reading should be similar to the manometer value obtained for previous samples. If it is substantially different than for previous samples or otherwise appears abnormal, a one point flow check should be completed.

The sampler timer should be prepared for the next scheduled run. Examine the timer wheel to insure it is set on the correct day and local standard time. If not adjust as necessary and note adjustments on the Particulate Sample Data Form. Repeat the process for each sampler to be used.

3.0 Changing an Exposed Sampler Filter

Prior to removing the exposed filter, turn on the sampler for a five minute period. After the five minute period, record the manometer reading and the elapsed time that the filter was exposed on the Particulate Sample Data Form.

The filter and cartridge should be checked for dirt, spider webs, or insects. Such large matter should be removed with tweezers if sample integrity can be maintained. Removal of foreign objects should be noted on the Particulate Sample Data Form. Damage to filter or loss of part of sample should also be noted on the Particulate Sample Data Form along with a detailed explanation.

The old filter should be removed and folded in half along the minor axis so that exposed portions are folded against exposed portions. The filters should then be placed inside a manila folder which is then placed inside a re-closable plastic bag and placed in a safe, clean and dry place until shipped. The number of the filter should be noted during this process and verified against the sample number on the Particulate Sample Data Form. Complete the Removal section of the form.
Make particular note in the Comments section of any change in activity in the area, weather conditions during the run (if possible), and any problem and associated corrective action.

When completed, place the Particulate Sample Data Form inside the re-closable plastic bag containing the manila folder with the exposed filter.

Remove the flow recorder circle chart and verify that the sampler I.D., the particulate filter number, and the day of the exposure of the filter have been placed on the chart. Record the elapsed time indicator reading on the back of the chart. Place the circle chart inside the re-closable plastic bag containing the manila folder with the exposed filter.

Repeat the procedure for each of the samplers containing an exposed filter.

4.0 Preventative Maintenance

Preventative maintenance for particulate samplers consists of the following:

- The air sampler is an instrument for collecting particles. Thus, it is obvious that the surfaces inside the particle collection area of the sampler should be kept clean. Most of the dirt accumulates on the top pan of the sampler. Clean these surfaces quarterly. At sampling locations with high levels of fugitive or wind-blown dust, the required cleaning schedule may be more frequent. It is a good practice to check the cleanliness of these surfaces when changing brushes. Cleaning is accomplished by simply wiping the surfaces with a wet cloth and drying. A special cleaning procedure is used for the SSI and is described in the following section.

4.1 Cleaning of the SSI Particle Shim

To insure correct particle size sampling, the collection shim should be cleaned once a month.

1) Unlatch and lift the upper chamber of the sampler inlet and secure it.

2) Move the hold-down clips away from the shim.

3) Remove the shim and place it on a clean flat surface away from the rest of the SSI assemblage.

4) Clean the interior surfaces of the SSI where the shim rests using a clean cloth.

5) Carefully clean the shim with a second clean cloth to avoid contamination.

6) Spray the shim with a coating of Dow Corning Silicone Spray #316. No substitute should be used. To apply the spray, hold the shim upright. Shake the spray can and point the arrow on top of the spray nozzle at the shim. Spray by holding the can upright 8 to 10 inches away. Allow 3 minutes for the solvent in the spray to evaporate leaving the final greased shim tacky, but not slippery. After drying, a cloudy white film is visible. Overspraying with the silicone will not hurt the performance of the inlet.

7) Lift the greased shim by the edges and place it on the second stage of the SSI with the greased side up.

8) Swing the two hold down clips over the edge of the greased shim to hold it securely in place.

9) Inspect the acceleration plate nozzles and clean as necessary using a soft clean cloth.

10) Lower the upper chamber of the sampler inlet back to its original position and secure it.

5.0 Calibration and Audit Schedule

Particulate samplers will be calibrated at project start-up. Thereafter, the normal calibration schedule for PM-10 particulate samplers is every three months. Non-scheduled calibrations would follow any repair, equipment maintenance or exceedance of an audit control limit.

Within 30 days of project start-up, audits will be performed on the particulate samplers. Thereafter, audits will be completed once per quarter.

6.0 Field Blanks

Field blanks are prepared and handled in the same manner and at the same time as the regular filter cartridges. The field blank is transported to the sample location on the sample installation day and again on the sample removal day. Fill out the appropriate information on the Particulate Sample Data Sheet. Upon arrival at the sampling location, place the field blank beside the PM_{10} sampler and remove the cover on the filter cartridge. Record the exposure start time, the date, and the weather conditions at the time of the exposure on the Particulate Sample Data Sheet. Perform the normal installation procedures for the scheduled sample run. After completing the installation procedures for the scheduled sample run, replace the cover field blank filter cassette. Record the exposure end time and calculate the elapsed time in minutes on the Particulate

Sample Data Sheet.

Follow the same procedures for the exposure of the field blank during the sample removal as was used during the sample installation exposure time. Calculate and record on the Field Blank Sample Data Sheet, the total field blank exposure time by adding the installation and removal elapsed time. PM_{10} field blank filters are removed from the filter cassettes and packed for shipping with the regular samples from the sample period using the same sample removal and packing method as is described in Section 4.0 above.

Particulate Sample Data Form

Project:______________________________ Filter/Sample Number: _______________

Site Name ___________________________ Sampler ID __________________________

Sampler Type: TSP PM-10 (circle one)

Flow Controller/Critical Flow Device S/N: ____

Installation

Filter was installed: Date__________________ By ___________

Elapsed time indicator reading: _____________________________________

Manometer Reading (in H_2O): ____

Sample will begin: Date & Time _______________________________________

Episodic *or* 24-hr sample: (circle one)

If episodic sample, anticipated sample run time: _______________________

Removal

Filter was removed: Date _________________ By ___________________

Manometer Reading (in H_2O): ____

Elapsed time indicator (ETI) reading: _______________________________________

Field Comments: ____

____

Office

Date sampler was last calibrated: ____

Average manometer reading (in H_2O): ______________________________________

Average actual flow rate: ____

Sample run time: ____

Office Comments: ____

____

MONTHLY FIELD CALIBRATION CHECK PROCEDURE
(for Tisch Volumetric-Flow-Controlled PM_{10} Samplers)

For PM_{10} samplers, a field calibration check of the operational flow rate is to be completed monthly. The purpose of this check is to track the sampler=s calibration stability. To perform a monthly calibration check for VFC type particulate samplers, the following equipment is needed:

1. Orifice transfer standard with a current calibration traceable to NIST.
2. A calibration manometer, with a 0 to 8 inch (0 to 200 mm) range and minimum scale divisions of 0.1 inch (1 mm).
3. A calibration manometer with a 0 to 40 inch (0 to 1000 mm) range and minimum scale divisions of 0.1 inch (1 mm) or other pressure measurement device for measurement of the sampler stagnation pressure. Ideally this manometer should be associated with the sampler.
4. Thermometer of appropriate range, capable of accurately measuring ambient temperature to the nearest 0.1° C and referenced to a NIST or ASTM thermometer within ∀0.5° C at least annually.
5. A portable aneroid barometer (e.g., a climber=s or engineer=s altimeter) capable of accurately measuring ambient barometric pressure over the range of 500 to 800 mm Hg (66 to 106 kPa) to the nearest mm Hg and referenced at least annually to within ∀5 mm Hg to a barometer of known accuracy.
6. The sampler=s most recent calibration relationship, i.e. the slope (m) and intercept (b).
7. A clean filter loaded into a filter cassette and a clean filter loaded into the orifice baseplate.

VFC samplers are normally flow checked with a clean filter installed into the baseplate and the adjustable resistance valve (if any) fully open, or without fixed resistance plates. A flow check filter should never be used for subsequent sampling because particles larger than 10 microns can be collected on the filter while the inlet is raised. The sample mass will be biased as a result of using a filter for both a flow check and subsequent sampling.

The stepwise procedure for a monthly calibration check of VFC type PM_{10} samplers is as follows:

1. Inspect all gaskets and seals on both the sampler and calibration equipment and replace any that are damaged.

2. Install the loaded baseplate and the orifice on the sampler. Make sure the orifice is not cross threaded on the baseplate. Tighten the baseplate nuts evenly on alternate corners to properly align and uniformly seat the gaskets. The nuts should be hand tightened only, too much compression can damage the sealing gaskets.

3. Leak test: Block the orifice with rubber (#1) stoppers, duct tape or other suitable means. Seal the pressure port with a rubber cap or similar device. Turn on the sampler. Avoid running the sampler for longer than 30 seconds at a time with the orifice blocked. This precaution will reduce the chance that the motor will be overheated due to the lack of cooling air. Such overheating can shorten the motor=s lifetime. It can raise temperatures to the point of defeating the electrical insulation which could result in fire or electric shock to the user.

   Gently rock the orifice transfer standard and listen for a whistling sound that would indicate a leak in the system. Leaks are usually caused either by a damaged or missing gasket between the orifice transfer standard and the baseplate or by cross threading of the orifice on the baseplate. All leaks must be eliminated before proceeding with the calibration check. When the system is determined to be leak free, turn off the sampler and unblock the orifice.

4. Inspect the connecting tubing of the manometers for crimps or cracks. Open the manometer valves and verify the free flow of the fluid. Adjust the manometers= sliding scales so that their zero lines are at the bottom of the meniscuses. Connect the transfer standard manometer to the transfer standard and the sampler stagnation pressure manometer to the stagnation pressure port. Ensure that one side of each manometer is open to atmospheric pressure. Make sure that tubing fits snugly on the pressure ports and on the manometers.

5. Read and record the following parameters on the calibration check form (F1023.1):

   X Date, location, and operator=s name
   X Sampler model and serial number (S/N)
   X Ambient barometric pressure, P_a (mm Hg)
   X Ambient temperature, T_a (K, K = °C +273.1)
   X Orifice S/N, certification date and relevant calibration information

6. Turn on the sampler and allow it to warm up to operation temperature, 3 to 5 minutes. The sampler inlet may be lowered over the orifice to act as a draft shield (if a shield is

not otherwise provided). Use a block to provide at least 2 inches of clearance at the bottom for air flow and for the manometer tubing.

Read and record the orifice manometer reading, ΔH, and the corresponding sampler relative stagnation pressure manometer reading, ΔH_{cfd} , on the calibration check form. Relative stagnation pressure is a negative pressure (i.e., a vacuum) relative to atmospheric pressure as measured by a manometer with one leg open to the atmosphere.

7. Turn off the sampler and remove the orifice transfer standard.

8. Install a normal filter cassette with a filter loaded, turn on the sampler and allow it to warm up once more to operating temperature.

9. Read and record ΔH_{cfd} for the normal operating flow rate. Turn off the sampler.

10. Calculate Q_a (orifice) by one of two methods:

Method A: Using the current orifice calibration curve, convert ΔH to Q_r by the formula,

$$Q_r = A(\Delta H)^B$$

Next convert Q_r to Q_a (orifice) by using the following formula:

$$Q_a \text{ (orifice)} = Q_r \cdot (760/P_a \cdot T_a/298)^{1/2}$$

Method B: Using the current orifice calibration curve, convert ΔH to Q_a in two steps,

i. $Q_{a\text{-}int} = [(\Delta H) \cdot (T_a / P_a)]^{1/2}$

ii. $Q_a \text{ (orifice)} = \{(1/m)\ (Q_{a\text{-}int} - b)\}$

Where:

Q_a (orifice) = actual volumetric flow rate as indicated by the transfer standard orifice, in actual m^3/min.
$Q_{a\text{-}int}$ = uncorrected intermediate flow rate value
Q_r = uncorrected reference flow rate value determined from manometer reading and orifice calibration curve (m^3/min.)
T_a = ambient temperature during calibration, K (K = °C + 273.1)
P_a = ambient barometric pressure during calibration (mm Hg)

11. Convert ΔH_{cfd} from inches of H_2O to mm Hg by multiplying by a factor of 25.4/13.6. Then calculate and record the absolute stagnation pressure:

P_1: $P_1 = P_a - \Delta H_{cfd}$

Where:

P_1 = absolute stagnation pressure (mm Hg)

P_a = ambient barometric pressure (mm Hg)
ΔH_{cfd} = relative stagnation pressure (converted to mm Hg)

12. Next, calculate and record both stagnation pressure ratios: P_1/P_a.

13. Calculate Q_a (sampler) by using the following equation:

    Q_a (sampler) = $\{[(P_1/P_a) - b]/m\} \cong T_a^2$

    Where b and m are the intercept and slope from the most recent sampler calibration.

14. Using Q_a (orifice) and Q_a (sampler) from the measurements with the orifice installed, calculate and record the QC percent difference as:

    QC% difference = $\{[Q_a(\text{sampler}) - Q_a(\text{orifice})]/Q_a(\text{orifice})\} \cong 100$

    Record this value on the calibration check form. If the QC% difference is within ∀7%, the sampler calibration check is acceptable. Those differences exceeding ∀7% will require recalibration of the sampler. If differences exceed ∀7%, double check all calculations and orifice certification numbers. Check again for leaks. If these appear okay, the monthly calibration check should be repeated before data invalidation is considered.

15. Using this percentage difference and Q_a (sampler) from the measurement with the normal cartridge and filter, calculate and record the corrected sampler flow rate as:

    Q_a (corrected sampler) = Q_a (sampler) $\cong$ {[100 - QC% difference]/100}

16. Determine the design flow rate percentage difference between the inlet design flow rate (1.13 act. m^3/min.) and the corrected sampler flow rate as:

    Design flow rate % difference = $\{[Q_a(\text{corrected sampler}) - 1.13]/1.13\} \cong 100$

    Record this design flow rate percentage difference on the Monthly Calibration Check Form. If the design flow rate percentage difference is less than or equal to ∀7% the sampler calibration check is successful. Those differences exceeding ∀7% will require recalibration. Differences exceeding ∀10% may result in the invalidation of all data obtained subsequent to the last calibration or last valid flow check. If differences exceed ∀7%, double check all calculations, the latest sampler calibration and the orifice calibration. Also check for leaks in the system. If these appear okay, the monthly calibration check should be repeated before considering invalidating any data.

PM_{10} SAMPLER MONTHLY CALIBRATION CHECK WORKSHEET
(For Volumetric-Flow-Controlled Samplers)

Project/Site Location______________________________

Date______________________________

Calibration Check by______________________________

Sampler No./ID______________________________

Motor Housing S/N______________________________

Critical Flow Device S/N______________________________

Sampler Last Calibrated on______________________________

Sampler Cal. Relationship: m_s = __________ b_s = __________

Site Elevation______________________________

Baro. Press. (P_a) (mm Hg)______________________________

Barometer______________________________

Temp. (T_a): (EC)__________ (K)__________

Thermometer______________________________

Calibration Check Orifice S/N______________________________

Orifice Certification Date______________________________

Orifice Cal. Relationship: m = __________ b = __________

Setup	ΔH Pressure Drop Across Orifice (in H_2O)	$Q_{a\text{-}int} = [(\Delta H)(T_a/P_a)]^{1/2})$	Using Orifice Cert. $Q_a(cal) = (1/m)\{Q_{a\text{-}int} - b\}$ (act m^3/min)	ΔH_{cfd} (in H_2O)	ΔH_{cfd} (mm Hg)	$P_1 = P_a - \Delta H_{cfd}$ (mm Hg)	P_1/P_a	$Q_a(sampler) = \frac{(P_1/P_a - b_s)*T_a^{1/2}}{m_s}$ (act m^3/min)
Orifice with loaded filter cassette								
Design (Operating) Condition with filter								

1. QC % Difference = $\left[\frac{Q_a\text{ (sampler)} - Q_a\text{ (orifice)}}{Q_a\text{ (orifice)}}\right]$ X 100 = __________

   where Q_a (sampler) is measured with the orifice installed

2. Q_a (corrected sampler) = Q_a (sampler) X $\left[\frac{100 - \text{QC \% Difference}}{100}\right]$ = __________

   where Q_a (sampler) is measured without the orifice installed

3. Design Flow Rate % Difference =

   $\left[\frac{Q_a\text{ (corr. sampler)} - 1.13}{1.13}\right]$ X 100 = __________

Appendix A-4

Calibration and Audit Procedures and Forms – PM_{10} Samplers

PM-10 HIGH VOLUME SAMPLER CALIBRATION PROCEDURE
(For Tisch Volumetric-Flow-Controlled PM_{10} Samplers)

1.0 Introduction

Calibration of a Tisch Environmental HighVolume Volumetric-Flow-Controlled (VFC) PM_{10} sampler's flow control device is necessary to establish the traceability of the field measurement to a primary standard through use of a flow rate transfer standard. Calibration of the individual sampler should be conducted according to an established schedule in order to maintain the viability of the data. A calibration of the sampler should be conducted immediately after the sampler has been placed in operation. Subsequent calibrations should be performed at 90-day intervals (quarterly) or after motor maintenance, repair of a flow device, deviation of flow by ±7% from the monthly one-point flow check value, or any time the sampler is moved to a new location.

Calibrations will be performed using an EPA calibrated orifice or an orifice calibrated with a positive displacement standard volume meter, such as a Rootsmeter, that is traceable to the NIST. Sampler calibration and calculations must be completed on site as the calibration of some VFC samplers may be affected by changes in line voltage. Sampler motors should operate for at least 5 minutes before calibration. Motors with new brushes should not be calibrated until after the brushes have been properly seated to the armature. Proper brush seating is accomplished by running the motor at half power (50-60 VAC) for a minimum of 20 minutes. The motor should return to full performance after an additional 30 to 45 minutes of operation at normal line voltage. The sampler calibration procedure requires obtaining at least four calibration flow rates.

For this calibration procedure for VFC type particulate samplers, the following conditions are assumed:

- The VFC sampler uses a choked-flow venturi to control the actual volumetric flow rate.
- The sampler flow rate is determined by measuring the stagnation pressure ratio.
- The sampler inlet is designed to operate at a constant actual volumetric flow rate of 1.13 act. m^3/min., and the acceptable flow rate range is ±10% of this value.
- The transfer standard for the flow rate calibration is an orifice device equipped with an integral variable resistance valve. The pressure drop across the orifice is measured by an associated manometer.
- The sampler will be calibrated in actual volumetric flow rate units (Q_a).

2.0 Calibration Equipment

To calibrate VFC type particulate samplers the following calibration equipment is needed:

1. Orifice transfer standard equipped with an integral variable resistance valve. The orifice transfer standard must have a current calibration traceable to NIST.

2. A calibration manometer, with a 0 to 8 inch (0 to 200 mm) or greater range and minimum scale divisions of 0.1 inch (1 mm).

3. A calibration manometer, with a 0 to 40 inch (0 to 1000 mm) range and minimum scale divisions of 0.1 inches (1 mm), or other pressure measurement device for measurement of the sampler stagnation pressure. Ideally this device should be associated with the sampler.

4. Thermometer of appropriate range, capable of accurately measuring ambient temperature to the nearest 0.1° C and referenced to an NIST or ASTM thermometer within ±0.5° C at least annually.

5. A portable aneroid barometer (e.g. a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure over the range of 500 to 800 mm Hg (66 to 106 kPa) to the nearest mm Hg and referenced within ±5 mm Hg to a barometer of known accuracy at least annually.

6. A scientific calculator capable of performing 2-variable linear regressions.

3.0 PM_{10} Calibration Procedure

The stepwise procedure for the calibration of VFC type PM_{10} high volume samplers is as follows:

1. Set up the calibration system as recommended by the manufacturer.

2. Inspect all gaskets and seals on both the sampler and calibration equipment and replace any doubtful ones.

3. Install the orifice transfer standard and its adaptor faceplate on the sampler. Make sure the orifice is not cross threaded on the faceplate. Tighten the faceplate nuts evenly on alternate corners to properly align and uniformly seat the gaskets. The nuts should be hand tightened only. Too much compression can damage the gaskets.

4. Leak Test: Block the orifice with small (#1) rubber stoppers, duct tape or other suitable means. Seal the pressure port with a rubber cap or similar device. Turn on the sampler.

   Caution: Avoid running the sampler for longer than 30 seconds at a time with the orifice blocked. This precaution will reduce the chance that the motor will be overheated due to the lack of cooling air. Such overheating can shorten the motor's lifetime. It can raise temperatures to the point of defeating the electrical insulation, which could result in fire or electric shock to the user.

   Gently rock the orifice transfer standard and listen for a whistling sound that would indicate a leak in the system. Leaks are usually caused either by a damaged or missing gasket between the orifice transfer standard and the faceplate or by cross-threading of the orifice transfer standard on the faceplate. All leaks must be eliminated before proceeding. When the system is determined to be leak free, turn off the sampler and unblock the orifice.

5. Inspect the connecting tubing of the manometers for crimps or cracks. Open the calibration manometer valves and verify the free flow of the fluid. Adjust the manometer's sliding scales so that their zero lines are at the bottom of the meniscuses. Turn the sampler digital manometer on and zero it. Connect the calibration manometer to the transfer standard and the sampler digital manometer (or other pressure instrument) to the stagnation pressure port. Ensure that one side of each manometer is open to atmospheric pressure. Make sure the tubing fits snugly on the pressure ports and on the manometers.

6. Record the following parameters on the PM_{10} High Volume Sampler Calibration Worksheet:

   - Date, location and calibrator's name
   - Sampler model and serial number (S/N)
   - Ambient barometric pressure (P_a), mm Hg
   - Ambient temperature (T_a), °C and K (K = °C + 273.1)
   - Orifice S/N, certification date and relevant calibration information

7. Turn on the sampler and allow it to warm up to operating temperature (3-5 minutes).

   Note: The sampler inlet may be partially lowered over the orifice transfer standard to act as a draft shield (if a shield is not otherwise provided). Use a block to provide at least 2 inches of clearance at the bottom for air to flow and for the manometer tubing.

   Read and record the orifice transfer standard's manometer reading, ΔH, and corresponding sampler relative stagnation pressure manometer reading, ΔH_{cfd}, on the calibration worksheet. Relative stagnation pressure is a negative pressure (i.e. a vacuum) relative to atmospheric pressure as measured by a manometer with one leg open to the atmosphere.

8. Calculate Q_a (orifice) by one of two methods:

   Method A: Using the current orifice calibration curve, convert ΔH to Q_a in two steps,

   i. $Q_{a\text{-int}} = [(\Delta H) \cdot (T_a / P_a)]^{1/2}$

   ii. $Q_a \text{ (orifice)} = \{(1/m)\,(Q_{a\text{-int}} - b)\}$

   Method B: Using the current orifice calibration curve, convert ΔH to Q_r by the formula,

   $$Q_r = A(\Delta H)^B$$

   Next convert Q_r to Q_a (orifice) by using the following formula:

   $$Q_a \text{ (orifice)} = Q_r \cdot (760/P_a \cdot T_a/298)^{1/2}$$

Where:

Q_a (orifice) = actual volumetric flow rate as indicated by the transfer standard orifice, in actual m^3/min.
$Q_{a\text{-}int}$ = uncorrected intermediate flow rate value
Q_r = uncorrected reference flow rate value determined from manometer reading and orifice calibration curve (m^3/min.)
T_a = ambient temperature during calibration, K (K = °C + 273.1)
P_a = ambient barometric pressure during calibration (mm Hg)

9. Calculate the stagnation pressure ratio (P_1/P_a) by first converting ΔH_{cfd} from inches H_2O to mm Hg by multiplying by a factor of 25.4/13.6. Then calculate and record the absolute stagnation pressure (P_1):

$$P_1 = P_a - \Delta H_{cfd}$$

Where:
P_1 = absolute stagnation pressure (mm Hg)
P_a = ambient barometric pressure (mm Hg)
ΔH_{cfd} = relative stagnation pressure (mm Hg)

Next, calculate and record the stagnation pressure ratio: P_1/P_a.

10. Repeat steps 7 through 9 by adjusting the variable orifice to obtain a different flow rate. At least four calibration flow rates are required to define the calibration relationship. At least three flow rates should be within the acceptable flow rate range of 1.017 to 1.242 act. m^3/min. We recommend taking at least 6 flow rate readings, as you may want to throw one or two points out after calculating the flow rate curve.

11. Upon obtaining all the calibration flow rates, perform a linear regression with the calculated orifice flow rates divided by the square root of the ambient temperature as the X variable (i.e. Q_a (orifice)/$T_a^{½}$), and the corresponding stagnation pressure ratio (P_1/P_a) as the Y variable.

    Calculate and record the linear regression slope (m), intercept (b) and the correlation coefficient (r). To be valid, the calibration should yield a regression equation with a correlation coefficient of $r > 0.990$ with no point deviating by more than ±0.04 m^3/min. from the value predicted by the regression equation. If r is less than 0.990, the calculated calibration curve may be examined point by point to determine if any (one or two) points need to be thrown out or if the calibration needs to be redone.

After performing the calibration, perform a single point operational flow rate verification to compare the VFC sampler's normal operating flow rate to the design flow rate, using the just obtained results from the calibration. The sampler's operational flow rate Q_a (sampler) is determined as follows:

1. Set up the PM_{10} sampler in its normal operating configuration. Place a filter in the normal sampling filter cassette and install it on the sampler. Close the inlet and secure

the six head bolts on the inlet.

2. Turn on the sampler and allow the motor to warm up for at least 3 minutes.
3. Record the ΔH_{cfd} value and turn the sampler off.
4. Calculate P_1/P_a, then Q_a (sampler), using the following equation:

$$Q_a \text{ (sampler)} = \{[(P_1/P_a) - b]/m\} \cdot T_a^{1/2}$$

where m and b are the slope and intercept from the just completed calibration.

5. Compare Q_a (sampler) with the inlet design flow rate (1.13 act. m^3/min.) using the following equation:

Design flow rate % difference = $\{[Q_a \text{ (sampler)} - 1.13]/1.13\} \cdot 100$

This design flow rate percentage difference must be within the allowable flow rate tolerance (i.e. ±10% unless otherwise specified by the manufacturer). However, this value should be well within ±7% to allow for some variation with ambient temperature. If this value is not within ±7%, recheck the calibration procedure and data for errors. Check the sampler for leaks, bad motor brushes, missing gaskets, incorrect motor type or abnormal line voltage. Because the VFC flow rate is not adjustable, the manufacturer must be consulted to resolve cases of substantially incorrect flow rates.

4.0 Elapsed Time Indicator (ETI) Calibration Procedure

Calibration of the sampler's actuation timer (digital or electromechanical) and the elapsed time meter should be performed using a calibrated reference timer and documented on the Timer Calibration Log. Timing equipment which does not meet the tolerances given below should be repaired or replaced and recalibrated prior to sample collection.

a. If a digital actuation timer is being used, its clock rate should be calibrated first. The actuation timer and reference timer may be simultaneously started at any time. Duration of the test period should be at least 24 hours. An allowable difference between the reference and actuation timer is ±2%. The elapsed time meter should then be calibrated during the sampling period using the activation timer's calibration results as a reference timer. An allowable difference between the actual sampling time and the indication obtained from the elapsed time meter is ±2 minutes over a 24-hour period.

b. If an electromechanical timer is being used, it should be calibrated over a 24-hour period which starts during a convenient time of day. The elapsed time meter should also be calibrated during the same period. The technician should be present to observe the actual starting and stopping times. Both should be within ±15 minutes of the pre-selected settings. The corresponding elapsed time meter should be within ±2 minutes of the actual time.

PM_{10} & HIGH VOLUME SAMPLER CALIBRATION WORKSHEET
(For Volumetric-Flow-Controlled Samplers)

Project/Site Location____________________
Date____________________
Calibrated By____________________
Sampler No./ID____________________
Motor S/N____________________
Critical Flow Device S/N____________________
Sampler Type (circle one) <u>**Hi-Vol**</u> <u>**PM-10**</u>

Site Elevation____________________
Baro. Press. (P_a)(mm Hg)____________________
Barometer____________________
Temp. (T_a):(EC)__________**(K)**__________
Thermometer____________________
Calibration Orifice S/N____________________
Orifice Certification Date____________________
Orifice Cal. Relationship m=__________ **b=**__________

Setup	ΔH PressureDrop Across Orifice (in. H_2O)	$Q_{a\text{-int}}$ From Orifice Calibration $Q_{a\text{-int}} = [(\Delta H)(T_a/P_a)]^{1/2}$	Q_a(orifice) = $(1/m)\{Q_{a\text{-int}} - b\}$	(X) $\frac{Q_a(\text{orifice})}{T_a^{1/2}}$	ΔH_{cfd} Pressure Drop as Configured (in H_2O)	(mm Hg)	$P_1 = P_a - \Delta H_{cfd}$ (mm Hg)	(Y) P_1/P_a	$Q_a$sampler $=\{(P_1/P_a - b_s)T_a^{1/2}\}(1/m_s)$ (act m^3/min)
Design (Operating) Condition with filter									*

m_s = __________

b_s = __________

r = __________

Design flow rate % difference = $\left[\frac{Q_a(\text{sampler})^* - 1.13}{1.13}\right] \times 100$ = __________

TIMER CALIBRATION LOG
(FOR PM-10 AND HIGH VOLUME PARTICULATE SAMPLERS)

PROJECT ____________________ SITE ____________________

TECHNICIAN ____________________

SAMPLER (TYPE, MODEL, ID, SERIAL NO.) ____________________
ELAPSED TIME INDICATOR (MODEL, SERIAL NO.) ____________________

SCHEDULED END DATE/TIME ________	ACTUAL END DATE/TIME ________	FINAL ETI READING ________
SCHEDULED START DATE/TIME ________	ACTUAL START DATE/TIME ________	INITIAL ETI READING ________
SCHEDULED NET TIME 24 HRS. 00 MIN.	ACTUAL NET TIME (a) ________	ETI NET TIME (b) ________

SAMPLER (TYPE, MODEL, ID, SERIAL NO.) ____________________
ELAPSED TIME INDICATOR (MODEL, SERIAL NO.) ____________________

SCHEDULED END DATE/TIME ________	ACTUAL END DATE/TIME ________	FINAL ETI READING ________
SCHEDULED START DATE/TIME ________	ACTUAL START DATE/TIME ________	INITIAL ETI READING ________
SCHEDULED NET TIME 24 HRS. 00 MIN.	ACTUAL NET TIME (a) ________	ETI NET TIME (b) ________

SAMPLER (TYPE, MODEL, ID, SERIAL NO.) ____________________
ELAPSED TIME INDICATOR (MODEL, SERIAL NO.) ____________________

SCHEDULED END DATE/TIME ________	ACTUAL END DATE/TIME ________	FINAL ETI READING ________
SCHEDULED START DATE/TIME ________	ACTUAL START DATE/TIME ________	INITIAL ETI READING ________
SCHEDULED NET TIME 24 HRS. 00 MIN.	ACTUAL NET TIME (a) ________	ETI NET TIME (b) ________

SAMPLER (TYPE, MODEL, ID, SERIAL NO.) ____________________
ELAPSED TIME INDICATOR (MODEL, SERIAL NO.) ____________________

SCHEDULED END DATE/TIME ________	ACTUAL END DATE/TIME ________	FINAL ETI READING ________
SCHEDULED START DATE/TIME ________	ACTUAL START DATE/TIME ________	INITIAL ETI READING ________
SCHEDULED NET TIME 24 HRS. 00 MIN.	ACTUAL NET TIME (a) ________	ETI NET TIME (b) ________

a Should agree to within ±30 min. of 24 hours.
b ETI net time should agree to actual net time to within ±2 minutes.

PM_{10} AND HIGH VOLUME PARTICULATE SAMPLER PERFORMANCE AUDIT PROCEDURE (For Volumetric-Flow-Controlled Samplers)

The audit procedure for volumetric-flow-controlled (VFC) high volume and PM_{10} particulate samplers assumes the following conditions:

- The VFC sampler utilizes a choked-flow venturi for flow-rate control.
- The sampler's flow rate is calculated from the pressure measured by a manometer (or other pressure measuring instrument) connected to the stagnation pressure port. (This procedure does not provide an audit of a continuous flow recorder that may be connected to the exit orifice port.)
- The sampler inlet is designed to operate at a flow rate of 1.13 m^3/min at actual conditions; the acceptable flow-rate fluctuation range is $\pm$10 percent of this value (i.e., 1.02 to 1.24 m^3/min).
- The calibrated, NIST-traceable transfer standard is an orifice type with an associated manometer.

The equipment needed to complete a performance audit of VFC type samplers is as follows:

- Audit orifice transfer standard with calibration traceable to NIST. The audit orifice transfer standard's faceplate or filter cassette may require modification to ensure a good seal during the performance audit. The audit orifice transfer standard should not be the same one that is used for routine calibrations and QC flow checks.
- An audit manometer, with a 0 to 300 mm (0 to 12 in.) or greater range and minimum scale division of 1 mm (0.1 in.).
- A thermometer, capable of accurately measuring temperature over an appropriate range to the nearest $\pm$0.1°C and referenced to an NIST or ASTM thermometer within 0.5°C at least annually.
- A portable barometer (e.g., a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure over the range of approximately 500 to 800 mm Hg to the nearest mm Hg and referenced within $\pm$5 mm Hg of a barometer of known accuracy at least annually.
- Audit worksheet
- A clean microquartz filter

The performance audit procedure for the VFC-type high volume and PM_{10} samplers is as follows:

1) Install a clean particulate filter in the VFC sampler. This may require the use of a filter cassette or a filter screen to support the filter. Install the audit orifice transfer standard's faceplate on the sampler. Check that the gaskets are in good condition and have not deteriorated.

Caution: Tighten the faceplate nuts evenly on alternate corners to properly align and uniformly seat the gaskets. The nuts should be hand-tightened only; too much compression may damage the sealing gaskets.

2) Install the audit orifice transfer standard with no resistance plate, or open the valve of a variable-resistance orifice wide open. For resistance plate-type orifices, make sure the orifice gasket is present and that the audit orifice transfer standard is not cross-threaded on the faceplate.

3) Leak test the audit system. Identify and correct any leaks in the audit setup before proceeding.

4) Inspect the site manometer and verify that the connecting tubing is in good condition and that the unit is zeroed out. If not, have the site operator set the manometer to read zero before they connect it to the stagnation pressure tap on the particulate sampler.

5) Take audit manometer and zero out any offset. Connect the audit manometer to the pressure port on the audit orifice transfer standard. Make sure the unconnected side of the manometer is open to the atmosphere. Make sure that the tubing fits snugly on the pressure port and on the manometer.

6) Read and record the following parameters on the PM_{10} and High Volume Audit Worksheet :

   ! Sampler location, date and time
   ! Sampler model and serial number (S/N)
   ! Names of the auditor and observer(s)
   ! Ambient temperature (T_a), °C and K (K = °C + 273)
   ! Ambient barometric pressure (P_a), mm Hg
   ! Audit orifice transfer standard's S/N and certification date
   ! The current calibration relationship for the particulate sampler

7) Turn on the sampler and allow it to warm up to operating temperature (3 to 5 min)

   Note: The sampler inlet may be partially lowered over the audit orifice transfer standard to act as a draft shield (if a shield is not otherwise provided). Use a block to provide at least 2 in. of clearance at the bottom for air flow and for the manometer tubing

8) When the sampler has warmed up to operating temperature, take the reading measured by the manometer at the pressure port on the audit orifice transfer standard and record as ΔH_{stg} on the PM_{10} and High Volume Sampler Audit Worksheet.

9) Have the site operator read the relative stagnation pressure using the manometer that normally is used to take pressure readings on the particulate sampler. Record the relative stagnation pressure as ΔH_{stg} on the audit worksheet. Convert from inches of water to mm of Hg by the equation:

   $$\text{mm Hg} = 25.4\ (\text{in } H_2O)/13.6$$

   or from in. of Hg to mm of Hg by the equation:

   $$\text{mm Hg} = 25.4\ (\text{in Hg})$$

10) Compute the absolute stagnation pressure, P_1, as: $P_1 = P_a - \Delta H_{stg}$

    and the absolute stagnation pressure ratio as: Stagnation pressure ratio $= P_1/P_a$

    Record the P_1/P_a ratio on the PM_{10} and High Volume Sampler Audit Worksheet.

11) Convert P_1 to Q_a(sampler) by using the most recent sampler calibration relationship.

12) Calculate Q_a (audit) by one of two methods:

Method A: Using the current orifice calibration curve, convert ΔH to Q_a in two steps,

i. $Q_{a\text{-int}} = [(\Delta H) \cdot (T_a / P_a)]^{1/2}$

ii. Q_a (orifice) $= \{(1/m)\,(Q_{a\text{-int}} - b)\}$

Method B: Using the current orifice calibration curve, convert ΔH to Q_r by the formula,

$Q_r = A(\Delta H)^B$

Next convert Q_r to Q_a (orifice) by using the following formula:

Q_a (orifice) $= Q_r \cdot (760/P_a \cdot T_a/298)^{1/2}$

Where:

Q_a (orifice) = actual volumetric flow rate as indicated by the transfer standard orifice, in actual m^3/min.
$Q_{a\text{-int}}$ = uncorrected intermediate flow rate value
Q_r = uncorrected reference flow rate value determined from manometer reading and orifice calibration curve (m^3/min.)
T_a = ambient temperature during calibration, K (K = ^{o}C + 273.1)
P_a = ambient barometric pressure during calibration (mm Hg)

13) Calculate the audit flow rate percentage difference between the sampler's indicated flow rate, Q_a(sampler), and the corresponding audit flow rate, Q_a(audit), determined from the audit orifice transfer standard as:

$$\text{Audit flow rate \% difference} = \left[\frac{Q_a(\text{sampler}) - Q_a(\text{audit})}{Q_a(\text{audit})}\right] * 100$$

Record this value on the audit worksheet. The audit flow rate percentage should be within $\pm$10% to pass this audit step.

14) Turn off the sampler and remove the audit orifice transfer standard.

15) Have the site operator set up the sampler in the normal sampling configuration (i.e., with a filter cassette, if normally used), turn on the sampler and allow it to warm up to operating temperature.

16) Have the site operator read the relative stagnation pressure from the PM-10 sampler manometer. Record the sampler's relative stagnation pressure ΔH_{stg}, and calculate the absolute stagnation pressure ratio, P_1/P_a, as specified in Steps 9 and 10. Record these data on the audit worksheet. Turn off the sampler.

17) Calculate the sampler's indicated operational flow rate, Q_a(sampler), using the P_1/P_a value obtained in Step 17 and the sampler's most recent calibration relationship. Record this flow rate on the PM_{10} and High Volume Sampler Audit Worksheet.

18) Calculate the corrected sampler flow rate using the following equation:

$$Q_a(\text{corrected sampler}) = [\,Q_a(\text{sampler})] * \left(\frac{100 - \text{Audit \% difference}}{100}\right)$$

where Q_a(sampler) is obtained from Step 18 and the audit flow rate percentage difference is obtained from Step 14. Record this value on the PM_{10} and High Volume Sampler Audit Worksheet.

19) Calculate the design flow rate percentage difference between the corrected sampler flow rate from Step 19 and the inlet design flow rate of 1.13 m^3/min as:

$$\text{Design flow rate \% difference} = \left[\frac{Q_a(\text{corrected sampler}) - 1.13}{1.13} \right] * 100$$

Record this value on the PM_{10} and High Volume Sampler Audit Worksheet.

20) If the design flow rate percentage difference is within ± 7 percent, the sampler calibration is acceptable. Differences exceeding ± 7 percent should be investigated. Differences exceeding ± 10 percent (or the acceptable flow-rate range specified by the inlet manufacturer) may result in the invalidation of all data obtained subsequent to the last calibration or valid flow check. Before invalidating any data, double-check the audit orifice transfer standard's certification, and all calculations.

PM_{10} & HIGH VOLUME SAMPLER AUDIT WORKSHEET
(For Volumetric-Flow Controlled Samplers)

Project/Site Location ______________________

Date/Time ______________________

Auditor ______________________

Observer ______________________

Sampler No./ID ______________________

Critical Flow Device S/N ______________________

Sampler Type (circle one): Hi-Vol PM_{10}

Sampler's Last Calibration: Date ______________________

m_s= ____________, b_s= ____________

Site Elevation ______________________

Baro. Pres. (P_a) (mm Hg) ______________________

Barometer ______________________

Temp. (T_a): (°C) __________ (K) __________

Thermometer ______________________

Manometer ______________________

Audit Orifice Serial No. ______________________

Audit Orifice Certification Date ______________________

m= ____________, b= ____________

Setup	ΔH Pressure Drop Across Orifice (in $H_2$0)	$Q_{a\text{-}int}$ From Orifice Calibration $Q_{a\text{-}int} = [(\Delta H)(T_a/P_a)]^{1/2}$	Q_a(audit) = $(1/m)\{Q_{a\text{-}int} - b\}$	ΔH_{cfd} Pressure Drop as Configured (in $H_2$0)	(mmHg)	$P_1 = P_a - \Delta H_{cfd}$ (mm Hg)	P_1/P_a	Q_a sampler $= [(P_1/P_a - b_s)T_a^{1/2}](1/m_s)$ (act m^3 min)
with orifice								
without orifice								

Audit Flow Rate Percentage Difference (2) ______________%

Q_a (corrected Sampler) (3) ______________ m^3/min

Design Flow Rate Percentage Difference (4) ______________%

---

2 Audit % Difference = [(Q_a(sampler) – Q_a(audit))/ Q_a(audit)] *100 where Q_a(sampler) is measured with the orifice installed

3 Q_a(corrected sampler) = Q_a(sampler) * [(100 – Audit % Difference)/100] where Q_a(sampler) is measured without the orifice installed

4 Design Flow Rate % difference = [(Q_a (corrected sampler)* - 1.13)/1.13] x 100

CALIBRATION PROCEDURE & WORKSHEET FOR A MET ONE BAM-1020 PM_{10} MONITOR
(Using a BGI deltaCal)

Project: ____________________ Site: ____________________
Technician: ____________________ Site Elevation: ____________________
Date/Time: ____________________

	Make	Model	S/N
Sampler	Met One	BAM- 1020	
Sampler Thermometer	Met One		
Cal Thermometer	BGI	deltaCal	
Cal Barometer	BGI	deltaCal	
Cal Flow Device	BGI	deltaCal	

I. **Leak check:** Make sure pump is off. Remove the inlet head and connect the leak check device (part no. BX-302 or equivalent). From the main menu, go to "TEST" then "TAPE" screen, advance the tape one window. From the main menu go to "TEST" then "PUMP" screen, turn on the pump. Make sure device is set to closed position. After a few seconds, look to see that the flow is below 1.0 LPM. Turn pump off. Remove leak check device.
PASS / FAIL circle one Flow: __________LPM (should be less than 1.0 LPM)

II. **Self test:** From the main menu, go to "TAPE" then "SELF TEST". PASS / FAIL circle one

III. **As Found Calibration:** Connect the NIST-traceable reference flow measurement device. From the main menu, go to "TEST" then "FLOW" screen. Record the temperature and pressure readings in the "As Found" table. Using the "NEXT" hot key, scroll through the Ambient Temperature "AT" field and Barometric Pressure "BP" field. When you get the cursor to the "FLOW 1" field, the pump will start. Let the pump run for five minutes at the point, then record your readings. Repeat this procedure for all three flows.

As Found

	BAM	REFERENCE	% Diff	Difference
Ambient Temperature (AT ºC)				
Barometric Pressure (BP mmHg)				
Flow 1 Reading (15.0 LPM)				
Flow 2 Reading (18.4 LPM)				
Flow 3 Reading (16.7 LPM)				

The temperature readings for the BAM and calibration thermometer should agree to within ± 2°C. The barometric pressure readings should agree to within ± 10mmHg. The manufacturer's Operation Manual calibration procedure desires that the sampler and reference flow rates should agree to ±1%. If the readings are outside of these limits, proceed to the "As Left" Calibration in Step IV.

IV. **As Left Calibration:** Following the procedure in Step III, enter the flow calibration screen. Calibrate your temperature and/or pressure if necessary. If you do not need to adjust a parameter, press the "NEXT" hot key to scroll through, and notate "NA" in the appropriate boxes. To calibrate the temperature/pressure, adjust the "STD" field to your reference device reading using the red arrow keys. Hit the "CAL" hot key, both the "BAM" and "STD" reading should now read the same. Record your adjusted values in the "As Left" table.

Hit the "NEXT" hot key to scroll to "FLOW 1", let equilibrate for five minutes; calibrate as necessary. To calibrate, set the "STD" field to your reference device reading and hit the "CAL" hot key. Record your readings in the "As Left" table. Follow this procedure to calibrate the remaining flows as necessary. The "CAL" hot key will only adjust "FLOW 3", and only after you have entered the "STD" for "FLOW 1" and "FLOW 2". This is a three point calibration; all points must be accurate to properly adjust the flow of the BAM.

As Left

	BAM	**REFERENCE**	**% Diff**	**Difference**
Ambient Temperature (AT °C)				
Barometric Pressure (BP mmHg)				
Flow 1 Reading (15.0 LPM)				
Flow 2 Reading (18.4 LPM)				
Flow 3 Reading (16.7 LPM)				

Hit "EXIT" to return to Main Menu. Leave unit in Main Menu reading "Status: ON"

Record End Time ________________

Comments:____
____
____
____
____
____
____
____

Site ______________ Date______________

Flow Rate Verification
Procedure & Worksheet
for a Met One BAM1020 PM_{10} Monitor
(Using a BGI deltaCal)

Project: ____________________ Site: ____________________
Technician: ____________________ Site Elevation: ____________________
Date/Time: ____________________

	Make	Model	S/N
Sampler	Met One	BAM- 1020	
Sampler Thermometer	Met One		
Cal Thermometer	BGI	deltaCal	
Cal Barometer	BGI	deltaCal	
Cal Flow Device	BGI	deltaCal	

I. **Leak check:** Make sure pump is off. Remove the inlet head and connect the leak check device (part no. BX-302 or equivalent). From the main menu, go to “TEST” then “TAPE” screen, advance the tape one window. From the main menu go to “TEST” then “PUMP” screen, turn on the pump. Make sure device is set to closed position. After a few seconds, look to see that the flow is below 1.0 LPM. Turn pump off. Remove leak check device.

Flow: __________LPM (should be less than 1.0 LPM) PASS / FAIL circle one

II. **Self test:** From the main menu, go to “TAPE” then “SELF TEST”. PASS / FAIL circle one

III. **As Found Calibration:** Connect the NIST-traceable reference flow measurement device. From the main menu, go to “TEST” then “FLOW” screen. Record the temperature and pressure readings in the “As Found” table. Using the “NEXT” hot key, scroll through the Ambient Temperature “AT” field and Barometric Pressure “BP” field. When you get the cursor to the “FLOW 1” field, the pump will start. Let the pump run for five minutes at the point, then record your readings.

	BAM	REFERENCE	% Diff	Difference
Ambient Temperature (AT °C)				
Barometric Pressure (BP mmHg)				
Flow Reading (16.7 LPM)				

C.F. Design Flow Rate = {(REF-16.7)/16.7} * 100 = __________%

The temperature readings for the BAM and calibration thermometer should agree to within ± 2°C. The barometric pressure readings should agree to within ± 10mmHg. The BAM and REFERENCE flows should agree to within ± 7%. The REFERENCE flow must be within ± 10% of design (16.7LMP). If any readings fall outside these limits, a calibration should be performed immediately.

Hit the “EXIT” key until the screen shows the main menu. Verify unit is sampling prior to exiting site.

Record End Time ______________

Comments: ____

AUDIT PROCEDURE & WORKSHEET FOR A MET ONE BAM-1020 PM_{10} MONITOR (Using a BGI deltaCal)

Project: ______________________________ Site: ___________________________
Auditor: ______________________________ Site Elevation: ___________________
Date/Time: ____________________________

	Make	Model	S/N
Sampler	Met One	BAM- 1020	
Sampler Thermometer	Met One		
Audit Thermometer	BGI	deltaCal	
Audit Barometer	BGI	deltaCal	
Audit Flow Device	BGI	deltaCal	

I. **Leak check:** Make sure pump is off. Connect the leak check device, BX-302 or BX-305. From the main menu, go to "TEST" then "TAPE" screen, advance the tape one window. From the main menu go to "TEST" then "PUMP" screen, turn on the pump. Make sure device is set to closed position. After a few seconds, look to see that the flow is below 1.5 LPM. Turn pump off. Remove leak check device.
PASS / FAIL circle one Flow: _________LPM (should be less than 1.5 LPM)

II. **Self test:** From the main menu, go to "TAPE" then "SELF TEST". PASS / FAIL circle one

III. **Audit:** Connect the NIST-traceable reference flow measurement device. From the main menu, go to "TEST" then "FLOW" screen. Record the temperature and pressure readings in the "As Found" table. Using the "NEXT" hot key, scroll through the Ambient Temperature "AT" field and Barometric Pressure "BP" field. When you get the cursor to the "FLOW 1" field, the pump will start. Let the pump run for five minutes at the point, then record your readings. Repeat this procedure for all three flows.

	BAM	REFERENCE	% Diff	Difference
Ambient Temperature (AT °C)				
Barometric Pressure (BP mmHg)				
Flow 1 Reading (15.0 LPM)				
Flow 2 Reading (18.4 LPM)				
Flow 3 Reading (16.7 LPM)				

Hit "EXIT" to return to Main Menu. Leave unit in Main Menu reading "Status: ON"

Record End Time _______________

Comments:____
____

Appendix A-5

Standard Operating Procedures and Forms – QA and QC

SITE CHECK PROCEDURE

1.0 Introduction

Monitoring sites are now often set up so that data are retrieved via cellular or satellite phone, radio telemetry, or other means on a daily or more frequent basis. This reduces the burden of frequent site visits. For this project, site checks will be scheduled every week to two weeks, depending on the site. The site inspection will include checking the physical integrity of the monitoring instrumentation and that the monitoring instrumentation is positioned as installed.

Site checks are part of the quality control process showing that the system is operating properly. Therefore, it is important that the site operator follows the operations procedures, completes the proper documentation, and promptly forwards a copy of all documents to the air monitoring project manager.

The primary documentation for the monitoring station site checks and site visits is the Site Check Procedure and Site Check Forms. The purpose of this procedure and form is to provide a checklist of the tasks that need to be performed and to document the current operating conditions.

2.0 Site Check Tasks

Using the site-specific Site Check Form, perform the following tasks each time a monitoring station is visited. Each Site Check Form should be completed as per instructions listed on the document. Note that air quality and meteorological data are collected in local *standard* time. Hence, times listed on the Site Check Forms should be noted in local standard time.

A. Site Entry - Inspection of Site Area

Upon reaching the site, inspect the premises. Check to see if the meteorological instrumentation, air samples, enclosures, fence, and tower are secure and appear normal.

B. Inspection and Checks of the BAM FEM PM_{10} Instrumentation

Inspect the BAM. Complete the checks listed on the Site Check Form. If any deficiencies are observed, the air monitoring project manager is to be notified immediately.

C. Inspection of Tisch FRM PM_{10} Sampler (for site with FRM sampler)

Inspect the Tisch PM_{10} sampler. If any deficiencies are observed, the air monitoring project manager is to be notified immediately.

D. Meteorological Instrumentation Checks – Visual Inspection (for site with meteorological tower)

Using the appropriate site-specific Site Check Form, inspect the monitoring instrumentation. If any deficiencies are observed, the air monitoring project manager is to be notified immediately.

E. Data Logger Check (for site with meteorological tower)

Verify data logger is working and indicates the correct year, date, and time (in standard time). To read the date and time, press ENTER to light up the display. Check that the data logger voltage is greater than 11.5 VDC.

F. Comparison of Observed Meteorological Conditions to Measured Values (for site with meteorological tower)

Prior to reading the current meteorological values, perform the following tasks:

Estimate wind speed, wind direction, and ambient temperature and record in the "Estimated Value" column. Next, record the instantaneous data values measured by the data logger. To reach the instantaneous data values from the initial display, select DATA and press ENTER, then select REAL TIME TABLES and press ENTER; select PUBLIC and press ENTER to see current readings.

Compare observed meteorological conditions with values given by the data acquisition instrumentation at the site. Are the observed values and the data logger measurements comparable (reasonably close) for each parameter?

If not, make note in the Comments section of the Site Check Form and *immediately* contact the air monitoring project manager.

G. Site Exit

Before leaving the site

- complete the Site Check Form,
- secure the enclosure(s),
- secure the site, and
- lock the fence gate.

3.0 Site Check Follow-Up

If any Site Check Form item is checked "NO," if any deficiencies are observed, or if the site technician has any concerns, the air monitoring project manager is to be notified immediately.

The completed Site Check Forms and any other completed documentation are to be submitted to the air monitoring project manager on a regular basis for review.

SITE CHECK FORM
BAM & FRM MONITORING STATION

PROJECT: Bear Run SITE NAME: (1)

Technician Name: ____________________

Date: ____________________ Time Arrived On Site: ____________ CST

Please explain all irregularities or problems in the Comments section.

SITE ENTRY

YES NO N/A

___ ___ ___ 1. Fence secure and gate locked?

___ ___ ___ 2. BAM-1020 enclosure secure upon arrival?

___ ___ ___ 3. Cell phone antenna pointed in correct direction?

___ ___ ___ 4. Tisch FRM PM10 sampler secure and intact upon arrival?

BAM-1020 CHECKS

Monitor operating and in "Operate" mode with "Status" reading ____________.

	Actual	BAM-1020
Date	________	________
Time (CST)	________	________

Filter Tape Needs Changing? (Yes/No) ____________

Enter the Normal Screen mode and record the following.

Last C* ____________

Last m ____________

Flow ____________

Ambient Pressure (mm Hg) ____________

* (if C = 0.985 ±0.010, notify the air monitoring project manager immediately)

SITE EXIT

YES NO

___ ___ 1. Tisch programmed for scheduled 1-in-6 day sampling run?

___ ___ 2. Set BAM display to Main Menu by hitting Exit key as necessary.

___ ___ 3. BAM-1020 and data logger enclosures closed and secure?

___ ___ 4. Date / Time Out: ________/________ CST

Comments: ____________________

SITE CHECK FORM
BAM MONITORING STATION

PROJECT: ________Bear Run________________ SITE NAME: __(2)________________________

Technician Name: ____

Date: ____________________________ Time Arrived On Site: _______________ CST

Please explain all irregularities or problems in the Comments section.

SITE ENTRY

YES NO N/A

___ ___ ___ 1. Fence secure and gate locked?

___ ___ ___ 2. BAM-1020 enclosure secure upon arrival?

___ ___ ___ 3. Cell phone antenna pointed in correct direction?

BAM-1020 CHECKS

Monitor operating and in “Operate” mode with “Status” reading ______________.

	Actual	BAM-1020
Date	________	___________
Time (CST)	________	___________

Filter Tape Needs to be Changed? (Yes/No) ______________

Enter the Normal Screen mode and record the following.

Last C*	__________________
Last m	__________________
Flow	__________________
Ambient Pressure (mm Hg)	__________________

* (if C = 0.985 ±0.010, notify the air monitoring project manager immediately)

SITE EXIT

YES NO

___ ___ 1. Set BAM display to Main Menu by hitting Exit key as necessary.

___ ___ 2. BAM-1020 and data logger enclosures closed and secure?

___ ___ 3. Date / Time Out: ____________/___________ CST

Comments: ____

____

____

____

SITE CHECK FORM
METEOROLOGICAL & BAM MONITORING STATION

PROJECT: Bear Run SITE NAME: (3)

Technician Name: ______________________________

Date: ______________________________

Time Arrived On Site: ______________ CST

Please explain all irregularities or problems in the Comments section.

SITE ENTRY

YES NO N/A

___ ___ ___ 1. Fence secure and gate locked?

___ ___ ___ 2. Tower intact and vertical? Guy wires okay?

___ ___ ___ 3. Cell phone antenna pointed in correct direction?

___ ___ ___ 4. BAM-1020 enclosure secure upon arrival?

___ ___ ___ 5. Data logger enclosure secure upon arrival?

METEOROLOGICAL INSTRUMENTATION CHECKS

YES NO N/A

___ ___ ___ 1. Horizontal wind speed propeller spinning freely? All 4 propeller blades intact?

___ ___ ___ 2. Wind direction vane intact and moving freely?

___ ___ ___ 3. Temperature radiation shield intact and appears normal?

___ ___ ___ 4. Radiation shield fans working?

___ ___ ___ 5. Precipitation gauge appears normal?

___ ___ ___ 5. Signal cables attached and appear okay?

DATA LOGGER CHECK

To read the date and time, press ENTER to light up the display.

	Actual	Data Logger
Month, Day, Year		
Time (CST)		

___ ___ 1. Is the CR1000 data logger scanning data properly (every second)?
Yes No (if not, note in Comments section below)

___ ___ 1. Does the CR1000 data logger indicate the correct year, day of year, and time?
Yes No (if not, reset to the correct value and note changes in Comments section below).

COMPARISON OF OBSERVED VALUES TO VALUES MEASURED BY DATA LOGGER

From the initial display, select DATA and press ENTER, then select REAL TIME TABLES and press ENTER, select PUBLIC and press ENTER to see current readings.

Parameter	Estimated (Observed) Value	Data Logger Reading
Horizontal Wind Speed (mph)	________	________
Wind Direction (deg)	________	________
Temperature @ 2-meters (°F)	________	________
Barometric Pressure	________	________
Battery Voltage (VDC)	> 11.5	________

___ ___
Yes No

2. Does the CR1000 data logger indicate reasonable values for each parameter? (if not, make note in Comments section below and immediately contact the air monitoring project manager).

BAM-1020 CHECKS

Monitor operating and in "Operate" mode with "Status" reading ____________.

	Actual	BAM-1020
Date	______	______
Time (CST)	______	______

Filter Tape Needs Changing? (Yes/No) ____________

Enter the Normal Screen mode and record the following.

Last C* ____________

Last m ____________

Flow ____________

Ambient Pressure (mm Hg) ____________

* (if C = 0.985 ±0.010, notify the air monitoring project manager immediately)

SITE EXIT

YES NO

___ ___ 1. Set CR1000 keyboard display to main screen by hitting ESC key numerous times.

___ ___ 2. Set BAM display to Main Menu by hitting Exit key as necessary.

___ ___ 3. BAM-1020 and data logger enclosures closed and secure?

___ ___ 4. Date / Time Out: __________/__________ CST

Comments: ____

CHAIN OF CUSTODY & SHIPMENT OF SAMPLES

1.0 INTRODUCTION

The process of shipping air quality samples begins with the proper collection and labeling of exposed filter samples and associated documentation. For PM_{10} samples, an Air Quality Chain of Custody Record (F0003.1) is to be completed listing the filter number, sample date, and analysis requested. The purpose of the Chain of Custody Record is to provide documentation on the handling of samples from the time they are collected until they are received by the laboratory and to provide the laboratory with analysis instructions.

1.1 Shipment Schedule

Samples for analysis will be shipped to the laboratory monthly or more frequently.

1.2 Shipping Containers

Each PM_{10} filter sample will be stored in a manila folder inserted in a sealed plastic bag. The bagged filter samples will be shipped in rigid containers, such as a sturdy cardboard container. PM_{10} filter samples, along with an Air Quality Chain of Custody Record, are to be shipped to McVehil-Monnett Associates at the address provided in Section 3 of this procedure.

2.0 CHAIN OF CUSTODY RECORD

To establish the records necessary to trace data and documentation possession from the time of shipment to the receipt at the laboratory, a Chain of Custody Record shall be completed and accompany every shipment of data and documentation.

The Chain of Custody Record shall contain the following minimum information:

- project name,
- filter number and sample ID,
- sample date,
- analysis requested, and
- signatures of people involved in the chain of possession.

Each person in custody of the data and documentation shall sign the Chain of Custody Record. The data and documentation shall not be left unattended unless placed in a secured container sealed with custody seals with the Chain of Custody Record inside the container.

3.0 DATA SHIPMENT

All packages will be shipped by registered delivery or hand carried by project personnel. PM_{10} samples are to be sent to the Air Quality Project Management office at the following address:

McVehil-Monnett Associates, Inc.
Data Analysis Coordinator
44 Inverness Drive East
Bldg. C,
Englewood, CO 80112

AIR QUALITY CHAIN OF CUSTODY RECORD

Contact Name	E-mail Address	
Address		
City	State	Zip Code
Contact Phone No.	Fax No.	
Project	Sampler Signature	

					Analysis Requested						Special Instructions
Lab ID	Site Name/ Sample Location	Filter No./ Sample ID	Sample Date	Sample Type (24 hr or episodic)	Gravimetric						Comments

Relinquished By (Signature) : Date/ Time	Received By: (Signature) Date/Time	Relinquished By (Signature) : Date/ Time	Total # of Containers
Received By (Signature) : Date/ Time	Relinquishe By: (Signature) Date/Time	Received By (Signature) : Date/ Time	Page ______ of ________

DATA VALIDATION AND ANALYSIS

1.0 Purpose and Responsibility

The site operator has the initial responsibility for distinguishing valid measurements from erroneous readings caused by malfunctioning instruments or source interferences. Once data have been acquired from the site station, they must be transformed, reorganized, and/or restructured so that an analyst can draw meaningful conclusions. This data transformation occurs in the Air Quality Task Management office and is referred to as data reduction. Essentially, it is the process of converting the data recording medium into a meaningful number (valid data).

2.0 Data Validation - Field

Data reduction will be greatly enhanced if the site operator is conscious of several aids in reviewing the data as it is collected. These are listed below:

1) Familiarity with typical diurnal range of values expected for the parameters measured. For example, the diurnal range of temperatures expected for the site during the season in which measurements occur and the expected wind directions for the area should be considered before the data are considered valid.

2) Familiarity with the type of instrument malfunctions that can occur.

3) Enter thorough and meaningful notes in on the Site Check Form and other field documents. For example, notes should include but are not limited to:

    a. Checks and/or adjustments to the equipment.
    b. Maintenance and repairs on the equipment.
    c. Calibrations and audits on the equipment.
    d. Summary of weather conditions.
    e. Unusual activities nearby that may impact data readings.

A copy of all site documentation including original calibration forms will be kept at the Air Quality Task Management office.

Procedures and techniques for handling and processing recorded air quality data are listed in the section which follows.

3.0 Data Registration and Validation - Office

The meteorological data will be automatically transferred daily from the site digital data logger via cellular telephone modem by a computer in the Air Quality Task Management office. The BAM FEM PM_{10} data will be manually or automatically transferred from the BAM via cellular telephone modem to the Air Quality Task Management office. The FRM PM_{10} data will be manually downloaded by the site operator and emailed to the Air Quality Task Management office weekly. At least three times each normal work week, the data will be inspected for the following.

1. Completeness
2. Data values reasonable for time of year and location
3. The beginning and ending dates and times of the data file will be verified.

The results of the inspection are documented using the appropriate Monthly Data Review Log.

Field documentation will be submitted to the Air Quality Task Management office monthly or more frequently. Upon receipt, the documentation will be reviewed by the Manager of Monitoring Services or his designee for the following:

-Field documentation filled out completely and properly.

-Any unusual occurrences or irregularities in instrumentation performance, data and documentation collection, or data and documentation shipment.

-Items which need to be attended to by the site operator or Air Quality Task Management office.

Upon review of the documentation and completion of any needed follow up actions, the field documents will be placed in the project files.

4.0 Data Processing and Validation

4.1 Meteorological Data

An outline of the digital data processing procedure is as follows:

A) Initial Processing
If necessary, the data sets will be run through a shortening software routine to clear the data set of extraneous data, if any, and to put it into the desired format.

B) Calculation of Hourly Averages
In this step, meteorological data are processed by a software routine from 15 minute averages and totals into hourly average and totals.

C) Sequence and Limits Checks
The data file is then run through a software routine to verify that the data are sequential and within specified value ranges for each parameter. The program also checks the data for atypical changes in values from one period to the next. Error files are produced to document potential problems in the digital data.

D) Data Analysis and Editing
The digital data are reviewed by an analyst. Invalid or missing digital data are identified. An invalid observation is classified as any of the following:

a) A data period of less than 45 minutes for any hour of the digital data record for any parameter;

b) Data not representative of the particular parameter.

c) All missing data.

Based on the review, the data file is then edited. Periods where calibrations or audits occurred will be noted by a special code number (777). All invalid observations will be coded as "999".

E) Final Processing

Next, the final output file is input into tabular format for printing and inclusion into data reports. The final output data file is them used as an input file to produce joint frequency distributions and wind roses.

When digital data processing is finished, the data are reviewed by a person other than the data processor. The data processing, initial data review, any edits based on the initial review, and the final review of the data sets are documented on the Meteorological Data Processing Log.

4.2 Particulate Data

4.2.1 BAM FEM PM_{10} Sampler

The data analysis technician will also transfer the raw PM_{10} concentration data into a computer spreadsheet. The PM_{10} concentrations are also output by the monitor in mg/act. m^3. Two-meter temperature data will be obtained from the site meteorological station or PM_{10} sampler and input into computer spreadsheet included in the computer file. Barometric pressure data will be obtained from the site meteorological station or PM_{10} sampler and entered into computer spreadsheet. (Should on-site barometric pressure data not be available, the annual average pressure for the site elevation will be substituted.) Using the following equation, the raw PM_{10} concentration data will be converted into micrograms per standard cubic meter (μg/std. m^3).

$$[PM_{10}]\ (\mu g/std.\ m^3) = [PM_{10}]\ (mg/act.\ m^3) \cdot (1000 \mu g/1\ mg) \cdot (P_{av}/P_{std}) \cdot (T_{std}/T_{av})$$

where:

$[PM_{10}]$ = concentration of PM_{10}

P_{std} = standard pressure of 760 mmHg

T_{std} = standard temperature of 298.1 K

T_{av} = average ambient temperature for the sampling period in Kelvin ($K = {}^oC + 273$)

P_{av} = average ambient barometric pressure for the sampling period

PM_{10} concentrations will then be reviewed and 7% of the values will undergo a quality control check including a re-calculation of the average data concentration value. PM_{10} concentrations will be reported in units of μg/std. m^3.

4.2.2 Filter-Based FRM PM_{10} Sampler

Subsequent to the receipt and review of the Particulate Sample Data Forms at the air quality task management office, the data analysis technician will input PM_{10} sample information into a spreadsheet type computer file. Generally, a computer spreadsheet Particulate Filter Data Log file will be set up for each sampler by site and monitoring quarter. Information input into the computer file from the Particulate Sample Data Form includes: sample date, filter number, sample run time, average manometer reading for the PM_{10} sampling run ($\overline{\Delta P_{ex}}$), which is determined by averaging the initial and final manometer readings for the sample period. The average temperature and average barometric pressure values for the sampling period are obtained and included in the Particulate Filter Data Log computer file. The data from the current calibration curve for the PM_{10} sampler are also entered in the computer file.

The sampler's average actual flow rate for the run (Q_a(sampler)) is calculated using the following equation:

$$\overline{Qa} = \{[\overline{\Delta P_{ex}}(T_{av}+30)/P_{av})]^{1/2} - b\}\,\{1/m\}$$

where:

$\overline{Qa}$	=the sampler's average actual flow rate for the sample period in actual cubic meters per minute
$\overline{\Delta P_{ex}}$	=average of initial and final sampler manometer readings, inches H_20
T_{av}	=average ambient temperature for the sample period, K (K = °C + 273)
P_{av}	=average barometric pressure for the sample period, mm Hg
b	=intercept of the current sampler calibration relationship
m	=slope of the current sampler calibration relationship

Next $\overline{Q_a}$(sampler) is converted to a standard flow rate (Q_{std}) equation:

$$Q_{std} = Q_a\,(\text{sampler}) * \frac{Pav}{Pstd} * \frac{Tstd}{Tav}$$

where P_{std} = 760 mm Hg and T_{std} = 298K

The volume (V) is calculated by:

$$V\ (\text{std m}^3) = Q_{std}\ (\text{std m}^3/\text{min}) * \text{Sample Time (min)}$$

Once the net weight (W_n) in milligrams of each PM_{10} filter (mass loading) is received from the project analytical laboratory, the PM-10 concentration (X) is calculated as follows:

$$X\ (\mu g/m^3) = \frac{Wn}{V} * 10^3$$

Finally, a hard copy printout of the computer spreadsheet Particulate Filter Data Log file is produced. The calculations and results for a minimum of one in ten filters are independently audited to verify that the correct data, calibration curves, and mathematical formulas were used.

If a value is incorrect, the auditor will draw a single line through the wrong number. The auditor will write in the correct value and initial and date the correction. All subsequent calculations which use the incorrect value will be checked. Upon completing this quality assurance procedure, the auditor will place at the top right corner of the Particulate Filter Data Log: "QA by (initials)"

METEOROLOGICAL MONITORING PROGRAM - MONTHLY DATA REVIEW LOG

Site: ______________________ **Year:** ____________

DATE	Data Period	Data Representative & Complete	Reviewed By	WS	WD	Sigma Theta	T-2m	Baro. Press.	Precip.	Batt Volt >12VDC	Corr.* Action? (Yes/No)

* If Yes, note details below.

Date/Comments:

BEAR RUN CONTINUOUS PM10 SAMPLER DATA
MONTHLY REVIEW LOG

Year: _______________ Month: _________________

DATE	Period of Data	Reviewed By	**Site** ______________________________				
			Data Representative & Complete	Flags? List, if any	Highest hrly [X] (µg/act.m^3) #	Highest 24-hr [X] (µg/act.m^3) #	Corr.* Action? (Yes/No)

** If Yes, note details below.*
 # If PM_{10} concentrations are above 150 µg/m^3 for an hourly average or 100 µg/m^3 for a 24-hour average, notify air monitoring supervisor immediately.

Date/Comments:

____
____
____
____
____

METEOROLOGICAL DATA PROCESSING LOG

Project: ____________ **Site:** ____________ **Year:** ________

Data Period		Raw Data Processed		File Name of Processed Data (*.toc or *.tot)	Processed Data In Tabular Format By Parameter/Month		Final Edits (Of *.toc or *.tot file and Parameter/Month file)		Final Review (Of *.toc or *.tot file and Parameter/Month file)	
Begin (Date/Hour)	End (Date/Hour)	By	Date		Reviewed By	Date	Edited By	Date	Reviewed By	Date

Data Processing Comments:

Data Review and Editing Comments:

PERFORMANCE AUDITS

Introduction

An audit is an integral part of the quality assurance program for any field measurement exercise. The performance audit is used to validate and document the accuracy of the data generated by a measurement system. These audits are performed independent of and in addition to the normal quality control checks by the technician.

A performance audit provides an independent assessment of the quality of data obtained by the ambient air monitoring methods. Independence can be achieved by following the guidelines listed below. The audit should be a true assessment of the measurement process under normal operation without any special preparation or adjustment of the system. Routine quality control checks conducted by the technician are necessary for obtaining and reporting high quality data, but they are not to be considered as part of the auditing procedure.

General Guidelines

1) A performance audit should be conducted only if calibration data from a recent calibration are available for the instrumentation being audited.

2) To achieve independence, a performance audit should be conducted by an auditor who is different from the site technician who conducts the routine measurements and calibrations.

3) To achieve independence, the auditor should use in the audit a set of calibrated instruments other than those used for calibrations and routine operations.

4) Before the audit, the auditor should explain in general the audit procedures that will be used.

5) The auditor should carry documentation verifying the calibration and traceability of the audit equipment used. If an observer requests to view these, the auditor shall present the certification documents.

6) During the audit, the auditor must follow the approved project audit procedures for each instrument.

7) During an audit, no changes are ever made to the instrument, to the calibration coefficients, or to anything affecting the response of any of the monitoring instrumentation.

8) The auditor should discuss the audit results with the observers at the conclusion of the audit. The results are not official until a final report is issued.

Upon initiating and completing an audit of a parameter, the auditor should note the local standard time on the audit form.

Completion of Audit

All monitoring equipment must be returned to its original sampling configuration upon completion of the audit. Audit calculations should be performed to ensure that no extraneous or inconsistent differences exist in the data before the auditor leaves the station. Audit forms for each instrument should be checked to insure that the audit has been fully and properly completed. At the end of the audit, the auditor should sign the form.

Audit Schedule

All monitoring instrumentation will be audited within 15 days of the commencement of field operations. Subsequent audits of the PM_{10} sampler and monitors will occur near the mid point of the four month sampling program. Performance audits of thePM_{10} sampler and monitors along with the meteorological instrumentation will also be completed within 15 days of the termination of monitoring.

Note, typically PM_{10} sampler and monitors would occur on a once in three month frequency. Performance audits of the meteorological instrumentation typically would occur on a once in six month frequency

Appendix A-6

Data and Maintenance Logs

METEOROLOGICAL STATION MAINTENANCE LOG

PROJECT: ____________________

SITE	Service Item	Service Dates					
____________ Meteorological Station	Horiz. WS Bearings						
	WD Bearings						
	WD Potentiometer						
	Radiation shield fan motor						

AIR MONITORING TASK SCHEDULE
for the
BEAR RUN PROJECT

Every 6th Day

1. Collect PM10 sample on Tisch FRM PM10 sampler.
2. Download and email Tisch FRM PM10 sample run data to MMA.

	June					July					August						September					October				
1																										
2																										

MONTHLY

	JUNE	JULY	AUG	SEPT	OCT
Complete one-point calibration flow check for all PM10 samplers					
Collect field blank for FRM PM10 sampler					
Clean PM10 inlets					
Submit samples, documentation and data to MMA					

QUARTERLY

	JUNE - AUGUST	SEPTEMBER - OCTOBER
PM10 sampler – change motor brushes		

5/12/12

Appendix A-7

Standard Operating Procedure and Form – PM_{10} Laboratory

LABORATORY PROCEDURES FOR GRAVIMETRIC ANALYSIS AND HANDLING OF AIR MONITORING PARTICULATE FILTERS

INTRODUCTION

The purpose of this log is to establish standard laboratory methods and record keeping in support of gravimetric analysis of the TSP (Total Suspended Particulate) and PM_{10} (Particulate Matter 10 microns or less) filters at McVehil-Monnett Associates (MMA). Standard laboratory procedures will insure the uniform and acceptable handling and weighing of all TSP and PM_{10} filters. The record section is to provide central and complete documentation of all quality control checks. Integrity of TSP and PM_{10} results from MMA will depend on how closely the procedures below are followed and how accurately the records are maintained.

I. LABORATORY PROCEDURES

This section contains procedures for filter selection and preparation, weighing, balance checks, relative humidity and temperature monitoring and record keeping. **CAUTION** - while handling filters, use clean cotton gloves or flat tipped tweezers. This policy is to be adhered to at all times.

A. FILTER SELECTION AND PREPARATION

1. Filter Selection - Filters used for TSP sampling are of the glass fiber type. PM_{10} samples are collected on microquartz fiber filters. Only filters having a collection efficiency of at least 99 percent for particles of 0.3 μm diameter, as measured by the dactyl phthalate (DOP) test are to be used. Inspect each filter visually with the aid of a light. Discard or return to the supplier filters with pinholes and other defects such as tears, creases or lumps. Remove loose particles with a soft brush.

2. Filter Identification - assign a serial number to each filter. Stamp this number on two diagonally opposite corners on the back side of the filter. Apply gentle pressure to avoid damaging the filter.

3. Filter Equilibrium - equilibrate the filter in the equilibration chamber for 24 hours prior to weighing to minimize errors in measuring the weight. Longer periods of equilibration will not affect accuracy. The equilibration chamber should be able to hold the temperature constant at a mean value between 15°C and 30°C with a variability of not more than 3°C. Relative humidity should hold constant at a mean value between 20 and 45 percent with a variability of not more than 5 percent.

4. Filter Weighing - clean filters are processed in lots. For filter pre-weighing, the minimum lot size is usually 25 filters. Before weighing the first PM-10 filter, perform a balance check by weighing three and five grams using standard class "S" weights. For TSP filters, perform a balance check using two and three gram Class S weights. Record the actual and measured weights, the date and the operator's initials in the Balance Logbook. If the actual and measured values differ by more than 0.5 mg (0.0005g), this should be reported to the supervisor before proceeding.

   If the actual and measured values agree to within 0.5 mg, weigh each filter to the nearest 0.1 mg. Weigh each filter within 30 seconds after removal from the equilibration chamber, record the tare weight and serial number of each filter in the Filter Weight Logbook. After every ten weighings, the operator will re-check the balance zero and record these check values in the Filter Weight Log. Clean filters must not be folded or creased prior to weighing or use.

5. Filter Handling - after weighing, each filter is to be placed in a filter cartridge or in a manilla folder (stamped with same number as the filter) which is to be inserted in its individual re-closable plastic bag.

B. WEIGHING EXPOSED FILTERS

1. Inspection and Documentation of Sample
   a. Upon receipt of the sample from the field, remove filter folders from its shipping envelope and examine the Particulate Sample Data Form to determine whether all data necessary to verify the sample for analysis and calculating concentrations have been provided. Void sample if (1) data is missing and unobtainable upon inquiry from field operator, and (2) sampler malfunction is evident, e.g. obvious faceplate gasket leakage.
   b. Locate the filter number in the Filter Weight Logbook.
   c. Examine the shipping envelope for sample material that may have become dislodged from filter. If such material is observed, recover as much as possible by brushing it from the envelope to the deposit on the filter with a soft camel hair brush.
   d. Examine the filter for insects imbedded in the sample deposit and if found, remove them with tweezers, using care to avoid disturbing more of the sample deposit than is necessary. If more than ten insects are observed, refer the sample to the supervisor for determination of acceptance or rejection.
   e. Record data verification, sample inspection, and removal of insects under remarks in the appropriate columns of the Filter Weight Logbook.

2. Filter Equilibration - equilibrate exposed PM_{10} and TSP filters in the equilibration chamber for 24 hours, additional equilibration time may be necessary for very damp filters. The equilibration chamber is climate controlled to meet the environmental conditions listed in Section I.A.3 above.

3. Gravimetric Analysis - perform a balance check as specified in Section I.A.4. and record the results. Weigh exposed filters to nearest 0.1 milligram on the analytical balance within 30 seconds after removal from the equilibration chamber. The operator should re-check the balance zero at least once for every ten weighings. The check values are to be recorded in the Filter Weight Log. Record the gross weight on the appropriate page in the Filter Weight Logbook.

C. TEMPERATURE AND RELATIVE HUMIDITY MONITORING OF EQUILIBRATION ENVIRONMENT

A seven day hygrothermograph is to be used for monitoring temperature and relative humidity in the equilibration chamber. Equilibration chamber will be maintained at the environmental conditions listed in Section 2.11.4.3 of EPA-600/R-94/038b and summarized in Section I.A.3 of this procedure. The hygrothermograph chart is to be changed on the first work day of each week. The charts are to be filed for documentation purposes.

The hygrothermograph is to be checked against a wet-bulb, dry bulb psychrometer (or equivalent certified device) every six months. A two point calibration is to be made by comparing readings made in the weighing room and then moving the hygrothermograph out of the conditioned weighing for a second comparison. If the difference between the hygrothermograph and corresponding psychrometer readings are within 6% for relative humidity or 2°C for temperature, continue use as is. If temperature or relative humidity disagrees by more, maintain and re-calibrate the hygrothermograph as required. Document the calibration results.

D. BALANCE QUALITY CONTROL CHECK

Accuracy of the balance is verified whenever a set of weighings is made. A set of three class "S" standard weights covering the weight range normally encountered in weighing filters is to be used in establishing accuracy. If at any time, one or more of the standard weights cannot be measured within 0.0005 grams of its stated value, the balance is to be re-calibrated. The manufacturer or their qualified representative is to perform the calibration and subsequent adjustments. In addition, the balance is to be calibrated when first purchased, yearly thereafter and at any time it has been moved or subjected to rough handling. Results of all balance checks and calibrations are to be recorded in the Balance Logbook.

II. OFFICE AND LABORATORY AUDIT PROCEDURES

A. CLEAN FILTER WEIGHING AUDITS

Weighing audits are to be made as soon as practical after the regular weighings. Clean filters are normally weighed in batches. This allows for sampling to be performed and corrections to be made before the filters are used. The audited filters are to be conditioned in the same manner as when they were originally weighed.

1. Divide into lots for initial filter weighing.
2. Randomly select for auditing four filters for re-weighing (if less than 50 filters). (If more than 50 filters, audit seven percent of the filters.)
3. If any one of the audit weights differ more than 2.8 mg from the original weight, re-weigh all the filters in the lot. Record results in the Filter Weight Log.

B. EXPOSED FILTER WEIGHING AUDITS

In order to allow for possible data correction, exposed filters should be audited as soon as possible after post-weights are completed.

1. Randomly select for re-weighing the appropriate number of filters as detailed in Section II.A. above.
2. Re-weigh filters in a lot if any audit shows weight difference by more than 5.0 mg from the original weight.
3. Accept the lot with no change if all audits are within 5.0 mg of the original weights.
4. Out of control points may indicate the need for re-calibration of the balance and/or improved operator technique. Re-weigh all of the remaining exposed filters in the lot if the balance requires re-calibration or the operation technique is changed.

Form No. 9050.1
Revision No. 1
Date 12/03

FILTER WEIGHING LOG

Filter Number	Filter Condition	Balance Zero	Tare Wt. (g)	Analyst/Date	Chamber RH (%)	Chamber T (°C)	Audit Wt. (g)	Audit Analyst/Date	Filter Condition	Balance Zero	Final Wt. (g)	Analyst/Date	Chamber RH (%)	Chamber T (°C)	Audit Wt. (g)	Audit Analyst/Date

BALANCE:
Sartorius 2003 MP1, Serial Number 2904027

Daily Q.C. Standard Weight Check

Date/Initials _____ _____ _____ _____ _____ _____

3.0000 g _____ _____ _____ _____ _____ _____

5.0000 g _____ _____ _____ _____ _____ _____

Book # __________

Page # __________

Comments:

Appendix B

2012 Ambient Particulate Monitoring Schedule

2012 Ambient Particulate Monitoring Schedule

Legend: □ = 1-in-6 day sample schedule   □ & □ = 1-in-3 day sample schedule

January

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	**4**	5	6	**7**
8	9	**10**	11	12	**13**	14
15	**16**	17	18	**19**	20	21
22	23	24	**25**	26	27	**28**
29	30	**31**				

February

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	**3**	4
5	**6**	7	8	**9**	10	11
12	13	14	**15**	16	17	**18**
19	20	**21**	22	23	**24**	25
26	**27**	28	29			

March

Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	**7**	8	9	**10**
11	12	**13**	14	15	**16**	17
18	**19**	20	21	**22**	23	24
25	26	27	**28**	29	30	**31**

April

Su	Mo	Tu	We	Th	Fr	Sa
1	2	**3**	4	5	**6**	7
8	**9**	10	11	**12**	13	14
15	16	17	**18**	19	20	**21**
22	23	**24**	25	26	**27**	28
29	**30**					

May

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	**3**	4	5
6	7	8	**9**	10	11	**12**
13	14	**15**	16	17	**18**	19
20	**21**	22	23	**24**	25	26
27	28	29	**30**	31		

June

Su	Mo	Tu	We	Th	Fr	Sa
					1	**2**
3	4	**5**	6	7	**8**	9
10	**11**	12	13	**14**	15	16
17	18	19	**20**	21	22	**23**
24	25	**26**	27	28	**29**	30

July

Su	Mo	Tu	We	Th	Fr	Sa
1	**2**	3	4	**5**	6	7
8	9	10	**11**	12	13	**14**
15	16	**17**	18	19	**20**	21
22	**23**	24	25	**26**	27	28
29	30	31				

August

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	**4**
5	6	**7**	8	9	**10**	11
12	**13**	14	15	**16**	17	18
19	20	21	**22**	23	24	**25**
26	27	**28**	29	30	**31**	

September

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	**3**	4	5	**6**	7	8
9	10	11	**12**	13	14	**15**
16	17	**18**	19	20	**21**	22
23	**24**	25	26	**27**	28	29
30						

October

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	**3**	4	5	**6**
7	8	**9**	10	11	**12**	13
14	**15**	16	17	**18**	19	20
21	22	23	**24**	25	26	**27**
28	29	**30**	31			

November

Su	Mo	Tu	We	Th	Fr	Sa
				1	**2**	3
4	**5**	6	7	**8**	9	10
11	12	13	**14**	15	16	**17**
18	19	**20**	21	22	**23**	24
25	**26**	27	28	**29**	30	

December

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	**5**	6	7	**8**
9	10	**11**	12	13	**14**	15
16	**17**	18	19	**20**	21	22
23	24	25	**26**	27	28	**29**
30	31					

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